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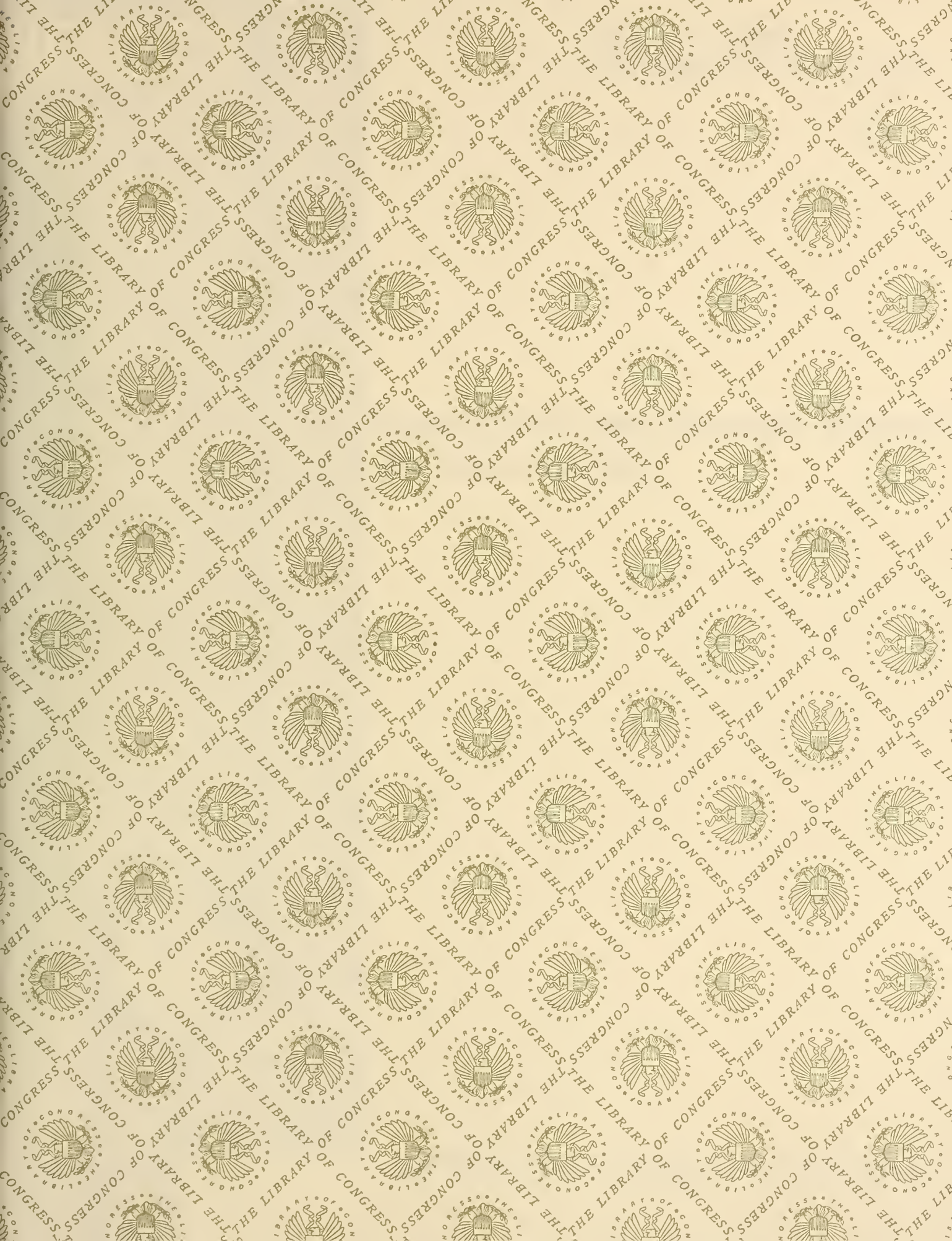
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Water Use in the Domestic Nonfuel Minerals Industry

UNITED STATES DEPARTMENT OF THE INTERIOR

Information Circular 9196

Water Use in the Domestic Nonfuel Minerals Industry

By Choon Kooi Quan

UNITED STATES DEPARTMENT OF THE INTERIOR
Donald Paul Hodel, Secretary

BUREAU OF MINES
T S Ary, Director

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environment and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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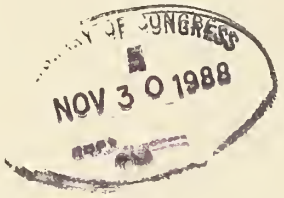

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

gal	gallon	mt	metric ton
gal/d	gallon per day	st	short ton
gal/st	gallon per short ton	tr oz	troy ounce
gal/yr	gallon per year	yr	year
mi^2	square mile		

WATER USE IN THE DOMESTIC NONFUEL MINERALS INDUSTRY

By Choon Kooi Quan[1]

ABSTRACT

Water availability is essential for mining and minerals processing. To provide government and industry with recent data for water use planning and management, the Bureau of Mines canvassed a number of U.S. producers of nonfuel minerals to determine their water use in 1984. Data were analyzed and compared with previously published data in order to examine historical trends in water utilization in the nonfuel minerals industry and to estimate water requirements in the year 2000.

Total water use in the domestic nonfuel minerals industry during 1984 was estimated at 2,267 billion gal, of which 571 billion gal was new water and 1,696 billion gal recirculated water. The largest users of water were the phosphate rock, iron ore, copper, sand and gravel, and crushed stone industries, together accounting for almost 90% of total used. More than one-half of all water was used in Florida, Michigan, and Minnesota. In the year 2000, total water use will amount to an estimated 2,679 billion gal, of which 810 billion gal will be new water and 1,869 billion gal recirculated water. Most of this water would be used in producing the foregoing suite of minerals.

[1]Physical scientist, Branch of Technical Analysis, Division of Policy Analysis, Bureau of Mines, Washington, DC.

INTRODUCTION

Water is one of the most important factors of production in the nonfuel minerals industry. It is used for mining crude ore and processing the ore to a product that can be sold as such (e.g., sand and gravel) or that can be converted to some other material by smelting and refining (e.g., copper metal from copper ore concentrates). The amount of water used varies according to location, nature of the ore, method of mining and processing, and State and local laws pertaining to water use and subsequent disposal. Generally, more water is used in processing than in mining of ore. Although the current practice is to recycle a substantial portion of the water used in many operations, significant amounts of new supplies are still required to make up for water that is lost through evaporation or incorporation in the final product. Thus, the availability of such supplies is essential to the continued operations of many existing mines. It is especially crucial for determining the technical and economic feasibility of developing new mines.

Although nationally the United States has an abundance of water, there could be local or regional shortages due to major climatological differences or seasonal drought. In areas where water is perennially or seasonally scarce and subject to competing uses, such as public supply, agriculture, and mining, economic expansion in one end-use sector could be made only at the expense of other sectors, unless appropriate water resource planning, development, and management procedures have been previously implemented. However, successful implementation of such procedures must necessarily be predicated on the availability of reliable data on water use, availability, and quality. Consequently, over the past few decades, several agencies and commissions have been authorized to periodically assess the Nation's current and projected water use and supply.

Beginning in 1950 and continuing at 5-yr intervals, the U.S. Geological Survey has published water use data for industrial applications, irrigation, public supply, rural needs, and thermoelectric power generation (*1-7*).[2] Estimated new water withdrawals increased from about 66 trillion gal in 1950 to 164 trillion gal in 1980, at an annual compound rate of about 3% (fig. 1). The two largest uses of water were for irrigation and thermoelectric power generation, together accounting for 72% to 81% of total withdrawals. Industrial uses of water, including mining, accounted for 7% to 8% of total withdrawals, but because of the sectoral aggregation employed, trends in water use in the nonfuel minerals industry could not be discerned.

In contrast, U.S. Bureau of the Census data (*8-11*) indicated that new water use in the nonfuel minerals industry rose from 0.51 trillion gal in 1954 to a high of 0.98 trillion gal in 1968, before declining to 0.55 trillion gal in 1983 (fig. 2). Largely offsetting the decline in new water usage was the steady increase in water recirculation from 0.32 trillion gal in 1954 to 1.39 trillion gal in 1978, after which the amount of water recirculated decreased slightly to 1.20 trillion gal in 1983. The Bureau of the Census data were based on official canvasses of the minerals industry at 5-yr intervals, starting in 1968. There was no canvass between 1954 and 1968.

Partly filling the gap between 1954 and 1968 was a Bureau of Mines canvass of water use in the minerals industry during 1962 (*12*). Results indicated that the domestic nonfuel minerals industry utilized about 1.49 trillion gal of water, of which 51% was new water and 49% recirculated water. More than 82% of all water was used in the production of copper ore, iron ore, phosphate rock, sand and gravel, and crushed stone (fig. 3). Ten States accounted for about 70% of total water used. In decreasing order of magnitude, they were Florida, Minnesota, Tennessee, Michigan, California, Arizona, Texas, New Mexico, Ohio, and Utah.

Perhaps the most comprehensive studies on water use in the domestic aluminum, copper, and iron and steel industries were reported by Conklin (*13*), Mussey (*14*), and Walling and Otts (*15*), respectively. Based on actual field surveys, these studies covered water use in the aluminum industry in 1952, copper industry in 1955, and iron and steel industry in 1957. Although some qualitative statements were made regarding the anticipated growth in aluminum, copper, and iron and steel production, no estimates were provided for future water use in these industries. These studies were augmented by a report on water use in the production of copper by Michaelson (*16*).

Mainly because of the potential for water shortages in the Western States, the Bureau of Mines investigated in great detail water use in the minerals industry of Arizona in 1960 (*17*), New Mexico in 1962 (*18*), Nevada in 1962 (*19*), Montana in 1963 (*20*), and Wyoming in 1964 (*21*). These investigations were based largely on site surveys of major mines and processing plants in those States. Projections of future water use were then made using certain assumptions about expected growth in mineral production. Some of these projections are no longer valid in light of present-day technological and economic conditions.

Other studies on water use and projections include those by the Senate Select Committee on National Water Resources in 1961 (*22*), Resources for the Future in 1971 (*23*), the National Water Commission in 1973 (*24*), the Water Resources Council in 1978 (*25*), and the Senate Committee on Environment and Public Works in 1980 (*26*). For the most part, population, technology, and economic activity were variables used in projecting future water use. However, the nonfuel minerals industry was not separately covered in these studies. Some methods for projecting water demand were reviewed by Lofting and Davies (*27*).

In the 25 yr since the first Bureau of Mines water canvass, the nonfuel minerals industry has undergone profound changes in the nature and scale of operations. Ores being mined today for copper and iron are of lower grade than those mined in 1962, resulting in the increased use of water. More water is also being recycled for use for economic or environmental reasons. At the same time, production of many minerals has been declining because of poor prices and foreign competition. It is therefore likely that water use trends and projections based on 1962 data may not be applicable under present circumstances. Consequently, in order to assist government and industry water use planning, the Bureau undertook a more recent canvass of the domestic nonfuel minerals industry. Results of the canvass are presented in this report.

[2]Italicized numbers in parentheses refer to items in the list of references preceding appendix A.

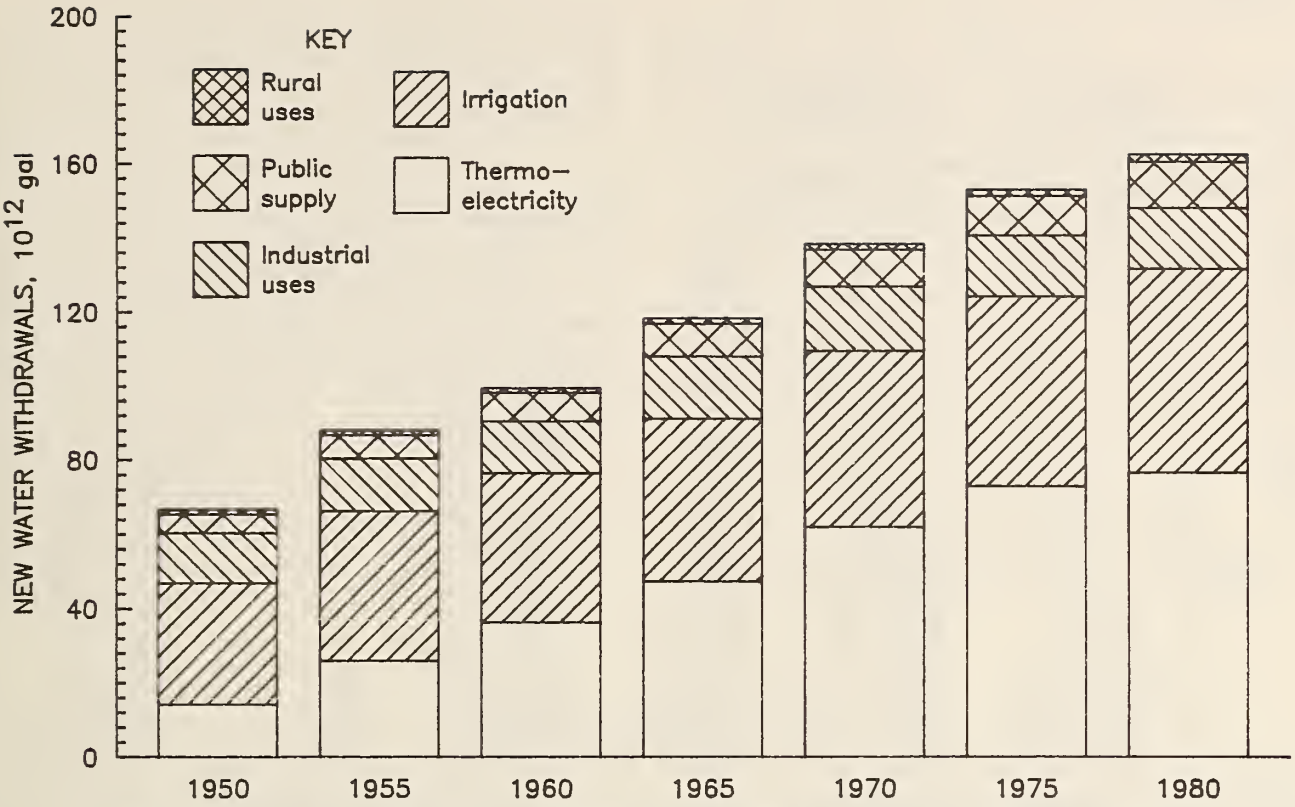

Figure 1.—New water withdrawals, by major end-use sectors, 1950-80. Data from U.S. Geological Survey (*1-7*).

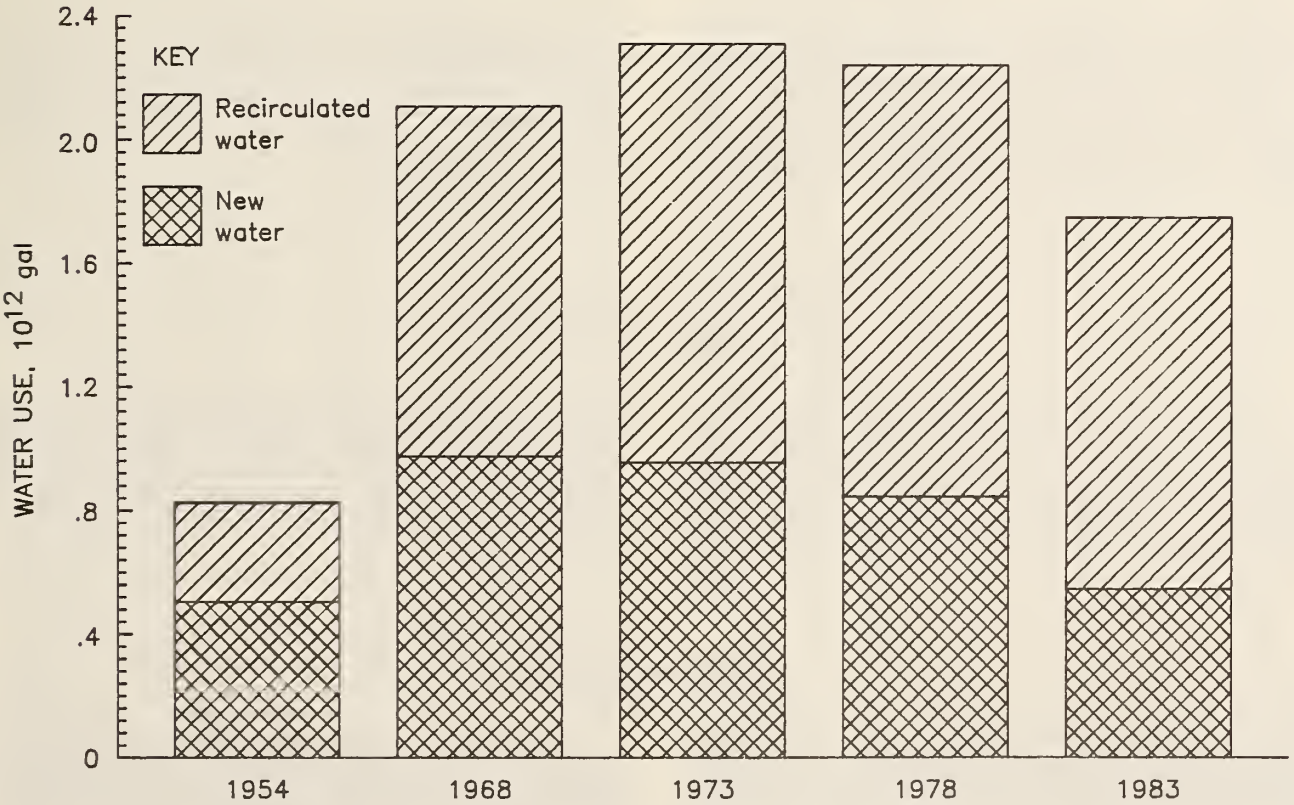

Figure 2.—water use in the nonfuel minerals industry, 1954-83. Data from U.S. Bureau of the Census (*8-11*).

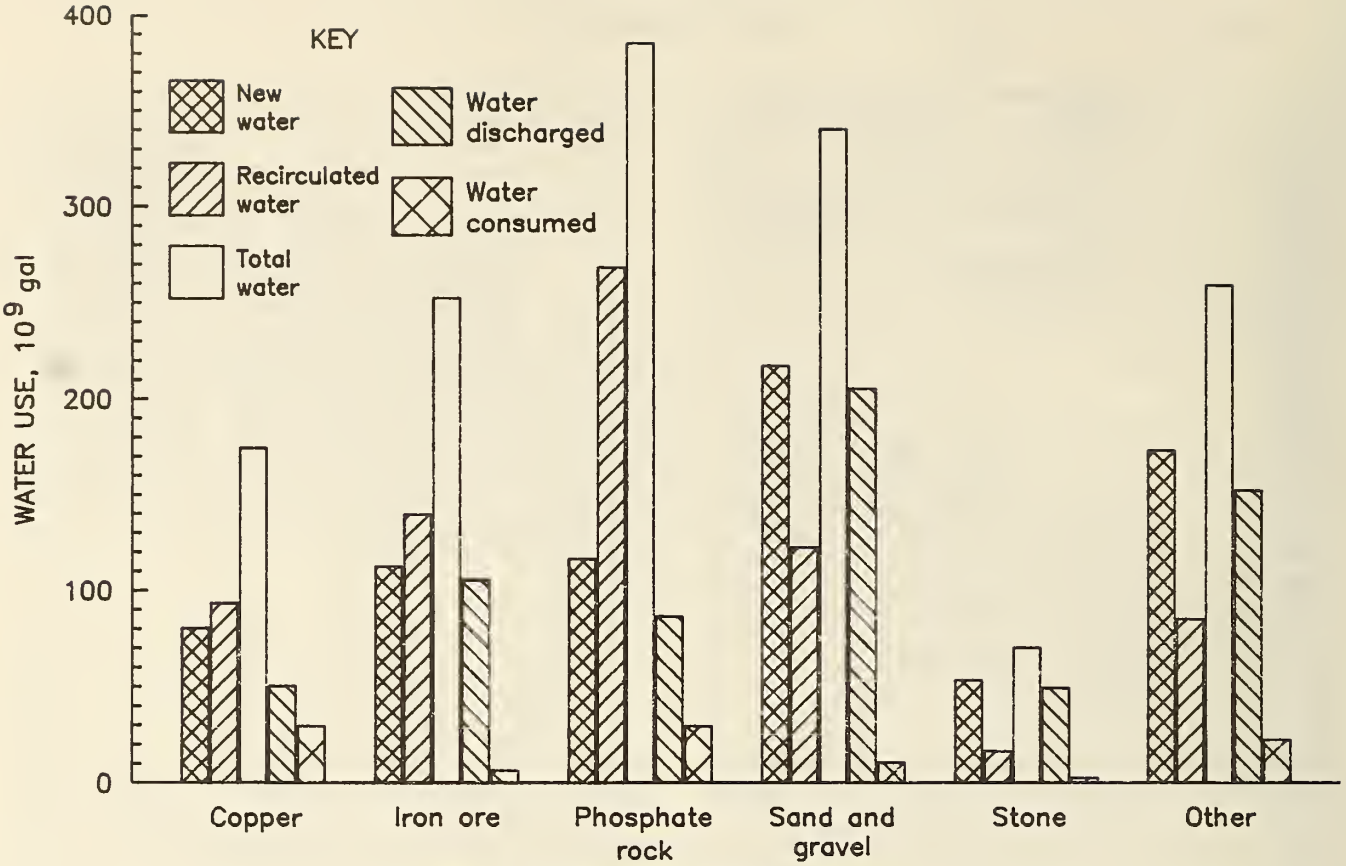

Figure 3.—Water use, by commodity, 1962 (*12*).

Water use by individual commodity and State is addressed in the report. Water use has not been aggregated by water resource region because of uncertainty in identifying political boundaries for each region. Also included in the report are historical trends in water use, major issues that have been identified, and estimates of water requirements in the year 2000.

For convenience in interpretation, salient data are presented graphically in the main body of the text, while statistical tables are relegated to appendixes. Where appropriate, data aggregation has been employed in some of the tables in order to avoid disclosing company proprietary information.

ACKNOWLEDGMENTS

The cooperation of respondents in providing data for the water canvass is gratefully acknowledged. Data processing personnel from the former Minerals Information directorate rendered invaluable assistance in securing U.S. Office of Management and Budget approval for conducting the canvass, in developing mailing lists, and in providing guidance in the use of a data base management system. Delores James, computer systems analyst, Branch of Technical Analysis, was largely responsible for the development of the water use data base and the generation of statistical tables, for which the author is grateful.

TERMINOLOGY

Some of the terms used in this report are broadly defined here as an aid to comprehension. The definitions may not necessarily coincide with other published definitions, nor are they to be construed as all-encompassing.

Nonfuel Minerals Industry: For the purposes of this report, the nonfuel minerals industry comprises all those establishments producing metallic and nonmetallic minerals except solid and liquid fuels, gases, cement, and lime.

Hereinafter, any specific reference to the production of metallic commodities such as copper, lead, zinc, etc. implies the mining and processing of their respective ores.

Mineral: This refers to the principal product, differentiated from waste material, in a mining or processing operation. It does not include byproducts such as molybdenum and gold recovered in copper mining.

Mining: This includes all activities that are involved in the extraction of minerals in surface and underground mines, such as drilling, blasting, loading, and transportation. It also includes solution-mining, dredging and hydraulicking, leaching, liquefaction, and evaporation.

Processing: This includes all physical and chemical processes that are used to separate minerals from waste material, such as washing, crushing and grinding, screening, table concentration or jigging, heavy-media separation, electrostatic or electromagnetic separation, and flotation. It does not include the smelting or refining of ores or the manufacture of cement and lime.

Crude Ore: This refers to the material that is first obtained from a mining operation before it undergoes processing to remove undesirable waste. Crude ore is sometimes sold or used without further processing.

Mine Production: This refers to production as measured by mine shipments, sales, or marketable production (including consumption by producers).

Value of Mine Production: This refers to the value of the principal product. Byproduct values are not included.

Water Use: This refers to water employed in mining, processing, and all other activities incidental to production.

New Water: This is water that is introduced from an external source into a given mine or plant for the first time, regardless of quality. New water is sometimes termed water intake, water withdrawal, or makeup water.

Recirculated Water: This is water that is recycled for further use in a mining or processing operation largely as a conservation measure. It does not include solutions recycled because of fixed metallurgical practices, such as a copper leaching solution containing sulfuric acid.

Total Water: This is the sum of new water and recirculated water. It is sometimes known as gross water.

Water Discharged: This is water that permanently leaves the mine or plant after having been used.

Water Consumed: This is the difference between new water and water discharged. It represents the water that is lost through evaporation or product incorporation.

THE WATER CANVASS

Data on water use in the domestic nonfuel minerals industry in 1984 was obtained by canvassing a selected sample of metal and nonmetal mines, using the questionnaire shown in appendix A. The questionnaire was adapted from Kaufman and Nadler (*12*), with slight modifications to minimize reporting time and requirements.

Respondents were asked to report all water, regardless of quality, that was used as a mining or milling agent, such as in the solution mining of salt, production of sulfur in the Frasch process, or flotation of mineral ores. Water used in the smelting and refining of metals or in the manufacture of cement and lime was to be excluded.

Plants and mines comprising an integrated operation were to report water usage on a single questionnaire. An integrated operation was defined as a mine and plant in the same county, operated as a unit by one company, and having an interrelated water system. Where mines and plants were located in different counties, separate estimates of water use in each county were requested.

Respondents with new water intake exceeding 1 million gal were asked to provide information on the source, quantity, and adequacy of their new water supply; the amount used and recirculated in mining, processing, or other related activities; the amount discharged or consumed; and the percentage of water treated prior to being used, recycled, or discharged. (Several respondents who reported little or no water intake but who used large amounts of recirculated water provided detailed information as well).

Respondents were advised to calculate water volumes using operational data or rated pump capacities where feasible. In the absence of such data, any reasonable estimates were acceptable.

The canvass was started with a first mailing in October 1985. A second mailing to all nonrespondents was made in January 1986. This was followed with telephone solicitations by Bureau personnel to a subset of the remaining nonrespondents during May and June. The canvass was declared officially closed in October 1986 when no more completed questionnaires were returned. Each completed questionnaire was reviewed for consistency and accuracy, after which the data were entered into a computerized data base for subsequent processing.

The sample of metal and nonmetal mines used in the canvass was derived from a population of about 6,000 establishments that had reported mine production during 1983 in response to a separate Bureau of Mines canvass. Included in the sample were 275 metal mines, each of which produced more than 1,000 st of crude ore, and 2,890 nonmetal mines, each of which produced more than 40,000 st of crude ore in 1983. Inadvertently, most of the construction sand and gravel mines were excluded from the sample because they had not been canvassed for their crude ore production in 1983. In 1984, there were some 5,000 sand and gravel mines reportedly producing in excess of 10,000 st each. As indicated later, water use in sand and gravel mines during 1984 was estimated by extrapolation from 1983 Bureau of the Census data.

The overall response rate in the water canvass was 66%, distributed by commodity and State as shown in appendix B. Not surprisingly, crushed-stone producers constituted the largest number of operations canvassed (71%) and the largest number of respondents (69%). Clay producers accounted for 8% of all mines canvassed and 9% of all respondents. As a result, the majority of respondents came from States producing crushed stone and clay.

The respondents accounted for 79% of crude ore produced in all metal mines but only 43% of crude ore produced in all nonmetal mines in 1984. The lower coverage ratio for nonmetal mines was largely due to the exclusion of most construction sand and gravel producers from the canvass sample. For the same reason, coverage in terms of mine value in 1984 was lower for nonmetal mines than for metal mines. Crude ore was used as the common

denominator because it was quantified in short tons across the entire spectrum of metallic and nonmetallic minerals covered in the canvass. In cases where crude ore production data were not available, the tonnage of marketable product was used as a proxy (e.g., evaporated salt and salt in brine). Similarly, where the value of mine production was unavailable, a shipment value was used in its place (e.g., for iron ore). It was felt that such usage of surrogate data would not greatly affect the analytical validity of the results of this study

Only 32% of the respondents had total water usage in excess of 1 million gal each in 1984. The vast majority (61%) used little or no water, and 7% of the respondents were inactive during the year. Of the 146 metal mines that were active, 74% used more than 1 million gal each. The ratio for the 1,797 active nonmetallic mines was only 32%, reflecting little water usage by a majority of respondent crushed-stone and clay mines. Consequently, States with many crushed-stone and clay producers during 1984 had proportionately fewer respondents using water.

More than two-thirds of all respondents using water during 1984 indicated they had water supplies that were adequate for 20 yr. Fourteen percent of the respondents had supply adequacy for 10 yr, and 10% had supply adequacy for 5 yr. About 6% of the respondents neglected to indicate the period of adequacy of their water supplies. Five producers of crushed stone, one producer of lode gold, and one producer of magnesite and brucite reportedly had inadequate supplies of water. These producers were located in the States of California, Nevada, New York, Oregon, Pennsylvania, and Wyoming. Together, they required an additional 206 million gal of new water per year.

ESTIMATED WATER USE IN THE NONFUEL MINERALS INDUSTRY IN 1984

Water use described herein represents those quantities of new and recirculated water employed in mining, processing, and related activities associated with the production of mineral ores. It does not include water that was simply pumped out of mines and discharged (mine dewatering) without prior utilization. Neither does it include water that was used in the downstream processing of ore (e.g., calcination of lime) or water that constituted an "ore" by itself (e.g., sea water from which certain chemical compounds were extracted).

For the most part, water use for individual commodities was estimated by simple extrapolation from respondent data. For example, the sample of respondent phosphate mines used 111.5 billion gal of new water to produce 172.4 million st of crude ore during 1984. By extrapolation, the entire phosphate industry, which produced a total of 182 million st of crude ore, used an estimated 117.7 billion gal of new water.

In the case of construction sand and gravel, where the number of mines sampled was negligibly small, an estimate of water use in the industry during 1984 was made by extrapolation from 1983 data. In 1983, U.S. production of construction sand and gravel amounted to some 655.1 million st. According to the Bureau of the Census (*11*), new water use in the industry was estimated at 8.51 billion gal. Thus, on the average, the industry used about 130 gal of new water per short ton of production in 1983. In 1984, total U.S. production of construction sand and gravel was 773.9 million st. Assuming the same average new water use per short ton of production as in 1983, new water use in the industry in 1984 was estimated at 100.5 billion gal. Similarly, the amount of water recirculated in the construction sand and gravel industry during 1984 was estimated at 45.4 billion gal.

WATER USE, BY COMMODITY AND TYPE OF WATER

Total water used consists of water that is introduced into the mine and plant for the first time (new water) and water that is recycled for use (recirculated water). As is often the case, much of the recycled water exists within a closed system, is used several times over, and is therefore difficult to quantify with any degree of confidence. Consequently, the amount of recirculated water reportedly used by respondents might have been overstated. Water consumed represents that quantity of new water lost through evaporation or incorporation into the product. It is derived from the difference between new water intake and water discharged.

Total water used by the nonfuel minerals industry during 1984 was estimated at 2,267 billion gal, of which three-fourths was recirculated water and one-fourth new water (see appendix C). Almost 60% of the water was used in the production of nonmetallic minerals. The largest use of water was in the production of phosphate rock, which accounted for one-third of the total used (fig. 4). The next largest uses were in the production of iron ore which accounted for 29% of total water used, sand and gravel (11%), copper (9%), and crushed stone (6%),

The two largest users of water also recycled the most water, possibly in compliance with State and local laws that limit the amount of wastewater that can be discharged into the environment. Thus, 90% of the water used in the production of iron ore and 85% used in phosphate rock production were recirculated. About 43% of total new water was consumed, either througn evaporation or incorporation in the product, and the balance discharged. The copper industry consumed more than three-fourths of its new water intake; although slightly larger in volume, the phosphate rock industry consumed only 52% of its new water intake.

Although the quantity of water discharged represented more than one-half of total new water, details on method of disposal or points of discharge were not requested from each respondent. During 1983, iron ore, phosphate rock, sand and gravel, and crushed stone operations directed 95%, 93%, 49%, and 72%, respectively, of their discharge water into streams and rivers (*11*). Another 34% from sand and gravel and 14% from crushed stone operations were directed into lakes and ponds.

WATER USE, BY COMMODITY AND TYPE OF OPERATION

Generally, two major activities are associated with the production of minerals—mining of crude ore and processing of the ore to a marketable product that can be used

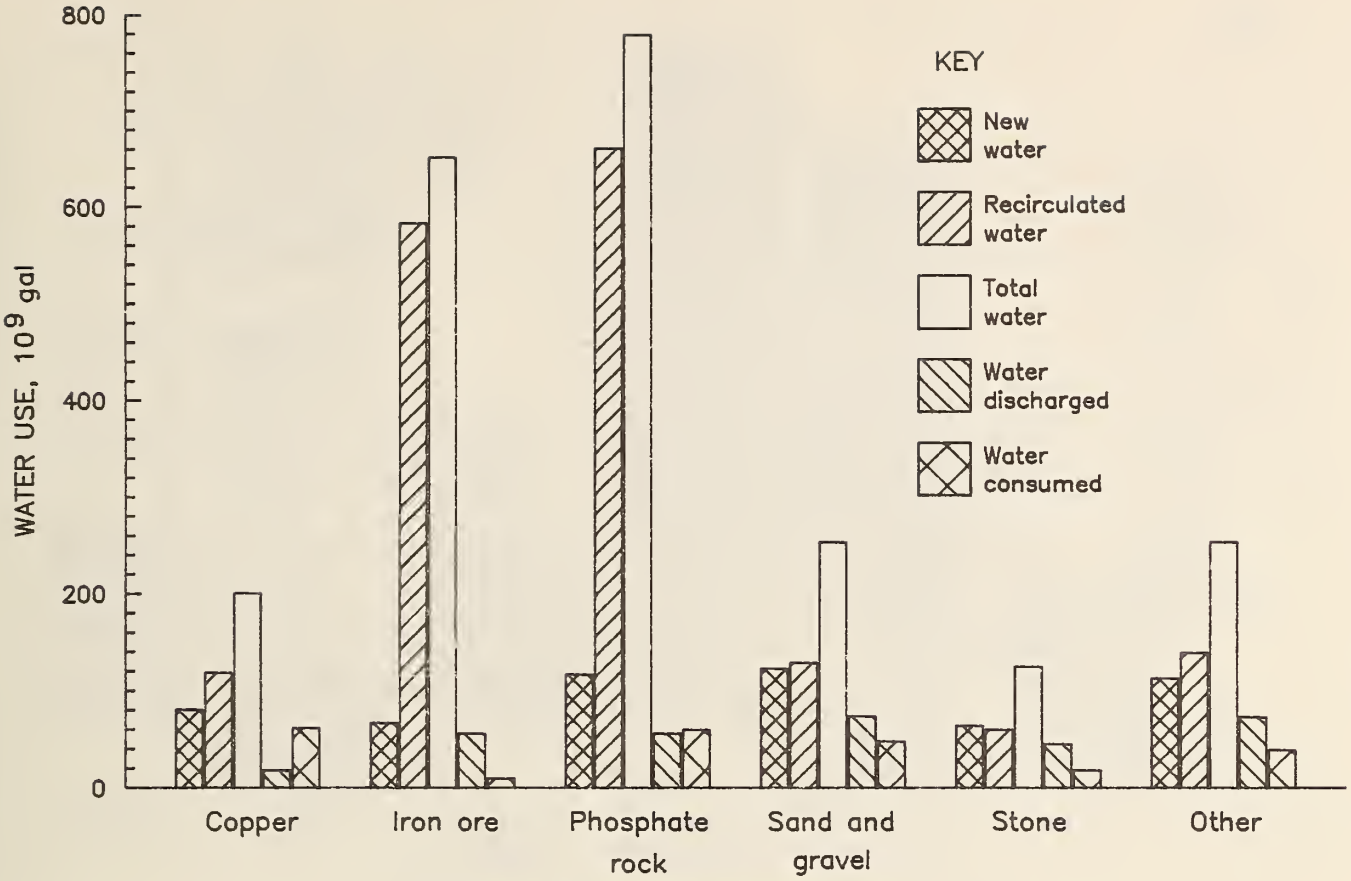

Figure 4.—Water use, by commodity, 1984.

as such (e.g., sand and gravel) or that can be converted to some other material by chemical or metallurgical processes (e.g., copper metal from copper ore concentrates). In some cases, as in the production of crushed stone, no processing of the crude material may be necessary. Water usage discussed herein applies only to mining and processing of crude ore. Water usage in smelting and refining or in the manufacture of chemical compounds, cement, and lime is not included.

Water is used in mining for drilling, dust control, dredging and hydraulicking of certain placer-type deposits, slurry transportation, solution extraction or leaching of ores and salts, and liquefaction of sulfur. The amount of water used will vary with the type of operation. For the most part, drilling and dust control require the least amount of water relative to, e.g., slurry transportation and dredging and hydraulicking.

In the processing of ore, large amounts of water may be needed in such diverse applications as washing, crushing and grinding, screening, table concentration or jigging, and flotation. While crushed stone and sand and gravel operations require only simple washing and screening to produce a marketable product, many metallic ores require complex flotation circuits for their concentration. Water usage in a selected number of flotation plants in the United States during 1985 is summarized by Martin, Edelstein, and Hyde (*28*).

Some water is also used in miscellaneous applications such as cooling and condensation, sanitation and drinking, and revegetation of mined lands. Total usage in these applications is usually minimal.

About 86% of total water used in the nonfuel minerals industry during 1984 was in the processing of crude ore, 10% was in mining, and 4% was in miscellaneous applications (fig. 5). Phosphate rock accounted for 35% of all water used in processing operations; iron ore, 33%; copper, 9%; sand and gravel, 8%; and crushed stone, 5%. In the case of iron ore production practically all of the water usage went into processing of crude ore. Similarly, almost 90% of the water used in phosphate rock production was for processing the crude ore.

The largest mining use of water was in phosphate rock production, which accounted for one-third of all water used in mining operations. It is quite likely that a substantial amount of water used in mining phosphate rock was for slurry transportation from the mine to the processing plant.

SOURCES OF NEW WATER, BY COMMODITY

Several sources of new water supply are available to the nonfuel minerals industry. These include surface water from streams, rivers, lakes, and reservoirs; water from mines; ground water; and water from municipal systems and other sources. While most of the water is self-supplied by company-operated systems, some is

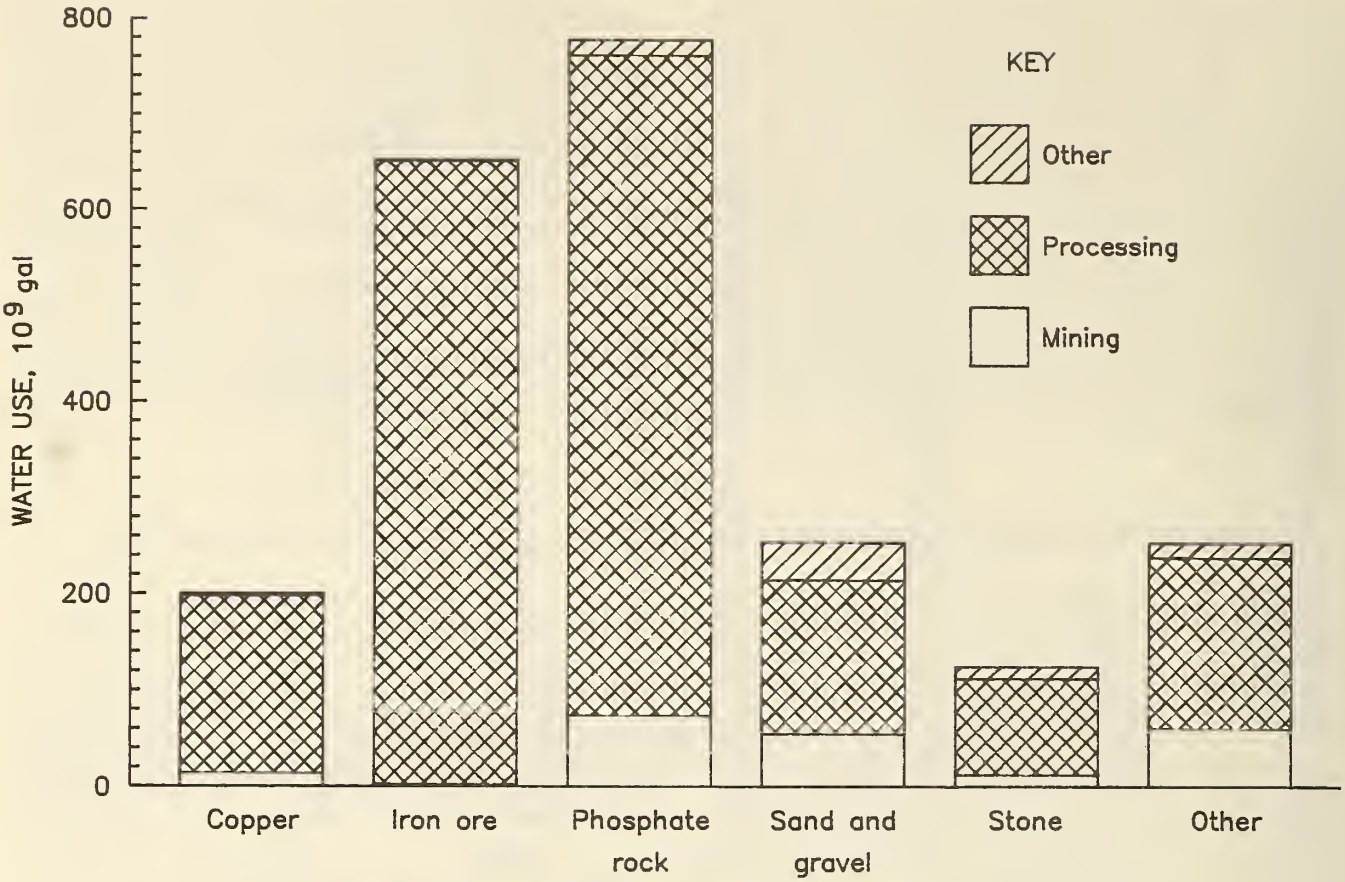

Figure 5.—Water use, by commodity and type of operation, 1984.

purchased from outside sources either to supplement self-generated supplies or else to provide a clean source of water for drinking, sanitation, and other essential uses.

In 1984, 36% of all new water intake was derived from ground water sources, 19% from lakes and reservoirs, 17% from streams and rivers, 17% from mines, and 11% from public water systems and other sources. For the most part, the quality of each supply source was not specified. However, in 1983, 69% of new water intake was fresh, 19% was brackish, and 12% was saline (*11*).

The largest uses of ground water were in phosphate rock and copper production, both accounting for about 58% of all ground water used (fig. 6). Iron ore production alone used 47% of all water from lakes and reservoirs. The single largest use for mine water was in processing construction sand and gravel, accounting for 40% of all mine water used.

WATER TREATMENT, BY COMMODITY

Water that is used for mining and processing, or for drinking and sanitation, often requires some form of prior treatment in order to obtain a quality suitable for each specified use. Similarly, water that is to be discharged may require prior treatment in order to comply with State and local environmental regulations. The type and extent of treatment varies with the source of water supply, type of use, and State and local wastewater quality standards. Available methods of water treatment include aeration, biological oxidation (bactericides), chlorination, filtration, pH control, precipitation, settling, softening, and other miscellaneous methods.

Because most process water was recirculated, more than three-fourths of all recirculated water was subject to some form of treatment prior to use during 1984 (fig. 7). In contrast, only 30% of all new water and 53% of all discharge water received treatment prior to use or discharge.

The five largest users—producers of copper, iron ore, phosphate rock, sand and gravel, and crushed stone—treated 83%, 80%, 85%, 50%, and 77%, respectively, of their recirculated water prior to use. Forty-nine percent of the new water used for copper, 9% for iron ore, 31% for phosphate rock, 16% for sand and gravel, and 32% for crushed stone was treated prior to use. The lower percentage for iron ore probably reflected the good quality of its fresh water intake. On the other hand, 69% of the discharge water from phosphate rock operations and 60% from sand and gravel operations received treatment prior to discharge, probably to remove excess slimes. About 41% of discharge water from copper, 30% from iron ore, and 49% from crushed stone was treated prior to discharge.

In all cases, details on the type and extent of water treatment were neither solicited from nor provided by the respondents. However, during 1983, 97% of the discharge water from iron ore, 92% from phosphate rock, 97% from sand and gravel, and 77% from crushed stone was treated by primary settling (*11*). The types of chemical reagents used in treating effluents from a selected number of flotation plants in the United States during 1985 can be found in reference *28*.

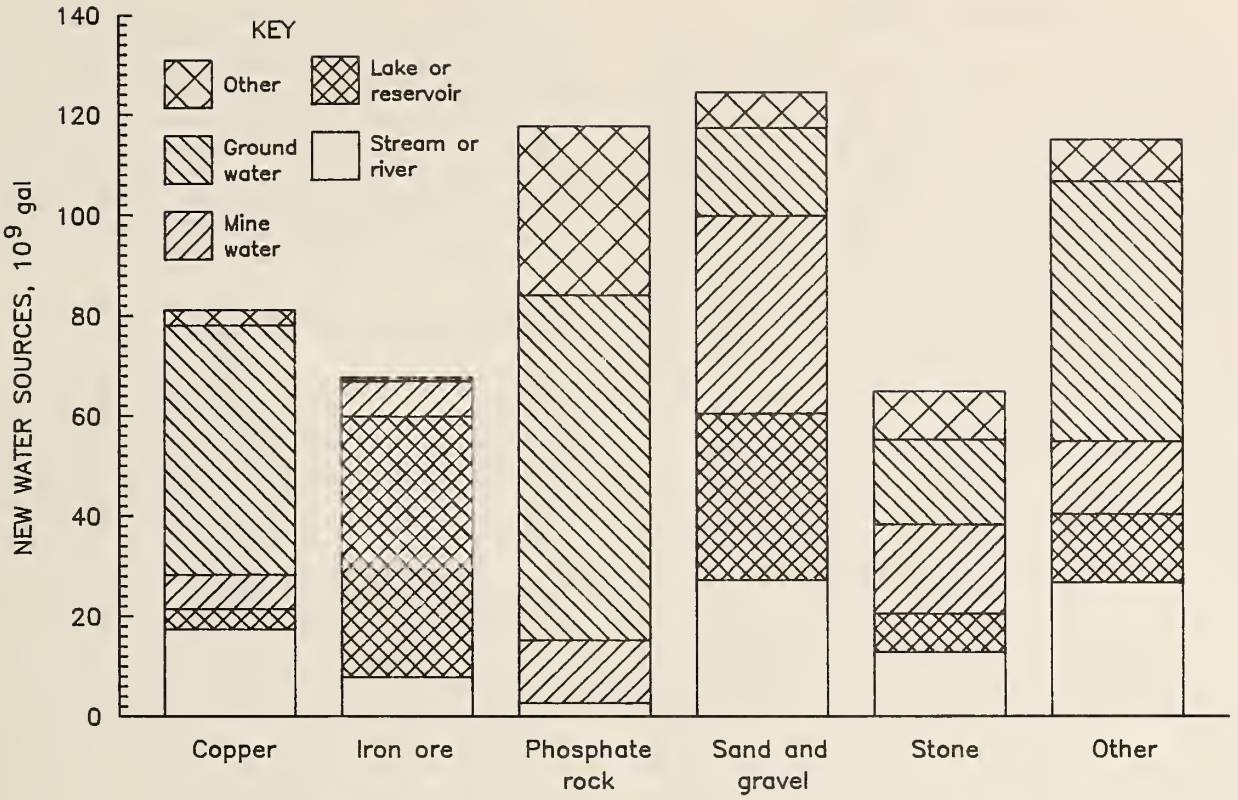

Figure 6.—Sources of new water, by commodity, 1984.

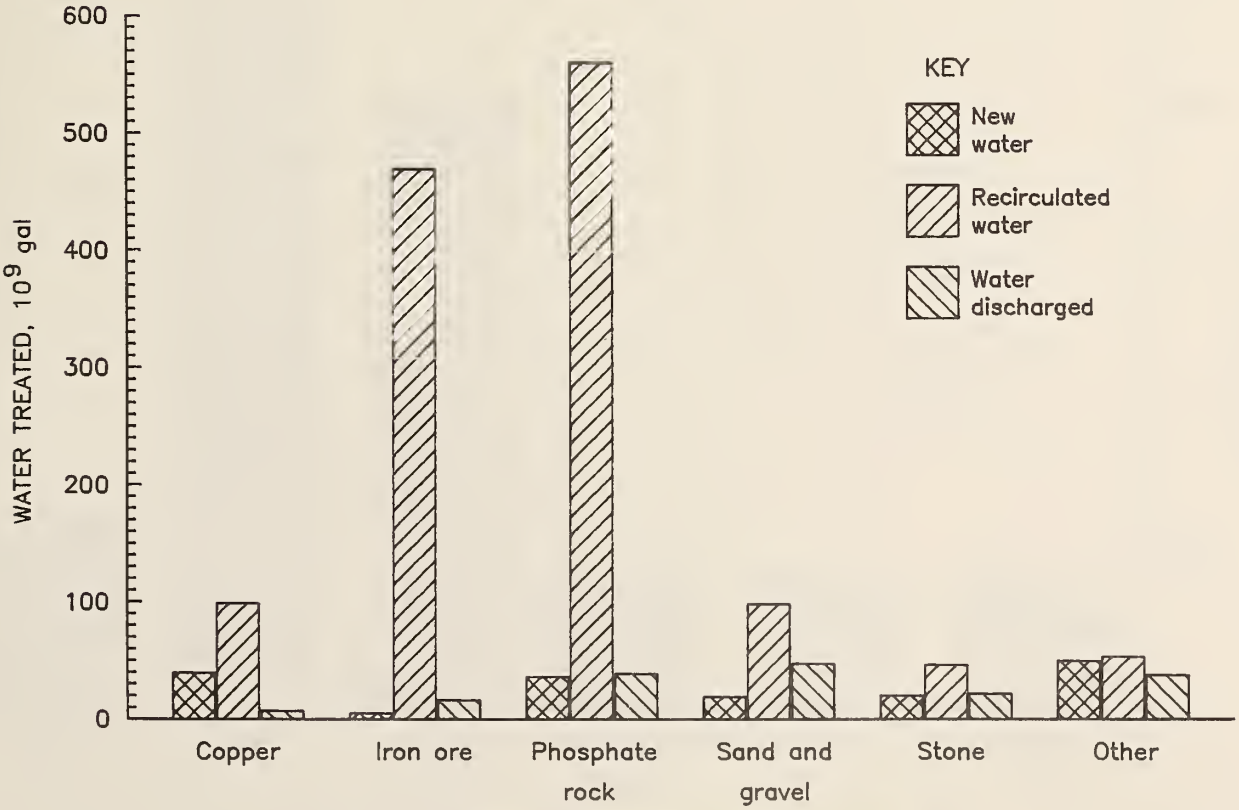

Figure 7.—Types of water treated, by commodity, 1984.

INTENSITY OF USE

For each category of water used, an index for the intensity of use per short ton of crude ore produced can be derived using the data in figures 4 and 8. This index represents an industry-wide average in the sense that it includes crude ore production from all nonusers as well as users of water during 1984. Similarly, an index for intensity of use per dollar of mine production can be derived using the data in figures 4 and 9. This index also represents an industry-wide average. Both indices are useful in examining trends in water use in the nonfuel minerals industry. Some caution must be exercised, however, in interpreting indices derived from low tonnages of crude ore or low values of mine production; such indices may be somewhat inflated.

Among major users of water, the phosphate rock industry appeared to have the largest total use per short ton of crude ore produced (4,280 gal), followed by iron ore (3,710 gal), and copper (1,040 gal), as indicated in figure 10. Because of averaging over large tonnages, total water use per short ton of sand and gravel and per short ton of crushed stone was only 320 gal and 130 gal, respectively. On the other hand, several low-tonnage minerals used more than 4,000 gal/st. Among these, evaporated salt used 4,910 gal/st and sodium carbonate, 5,460 gal/st. Overall, metal mines used 1,980 gal and nonmetal mines 640 gal for each short ton of crude ore produced. The lower index for nonmetal mines was due to the very large combined tonnage of sand and gravel and crushed stone used in its derivation.

In terms of mine value (fig. 11), phosphate rock production also appeared to have the largest total use of water per dollar of mine production (660 gal), followed by iron ore (290 gal), copper (130 gal), sand and gravel (100 gal), and crushed stone (30 gal). However, several minerals with relatively low production values also used more than 300 gal per dollar of mine production. Among these, vanadium used 340 gal, feldspar, 440 gal, and placer gold, 600 gal. On the whole, metal mines used 160 gal and nonmetal mines 110 gal for each dollar of mine production.

WATER USE, BY STATE AND TYPE OF WATER

Generally, water usage (new or recirculated) by individual States depends on the minerals produced, type of production process, and availability of water. During 1984, Florida was by far the largest user, accounting for about one-third of all water used in metal and nonmetal mines in the United States (fig. 12). Almost 90% of this water was used in the phosphate rock industry. The next largest users of water were Minnesota, which accounted for 20% of all water used, and Michigan (10%). About 98% of the water in Minnesota and 89% in Michigan was used in the iron ore industry. Three Western States—Arizona, New Mexico, and Utah—together utilized about 10% of all water. Almost 88% of the water in these three States was used in the copper industry. Individually, the next four largest users were North Carolina, which accounted for 6% of all water used, California (3%), Texas (2%), and Illinois (2%). Most of the water in North Carolina was used in

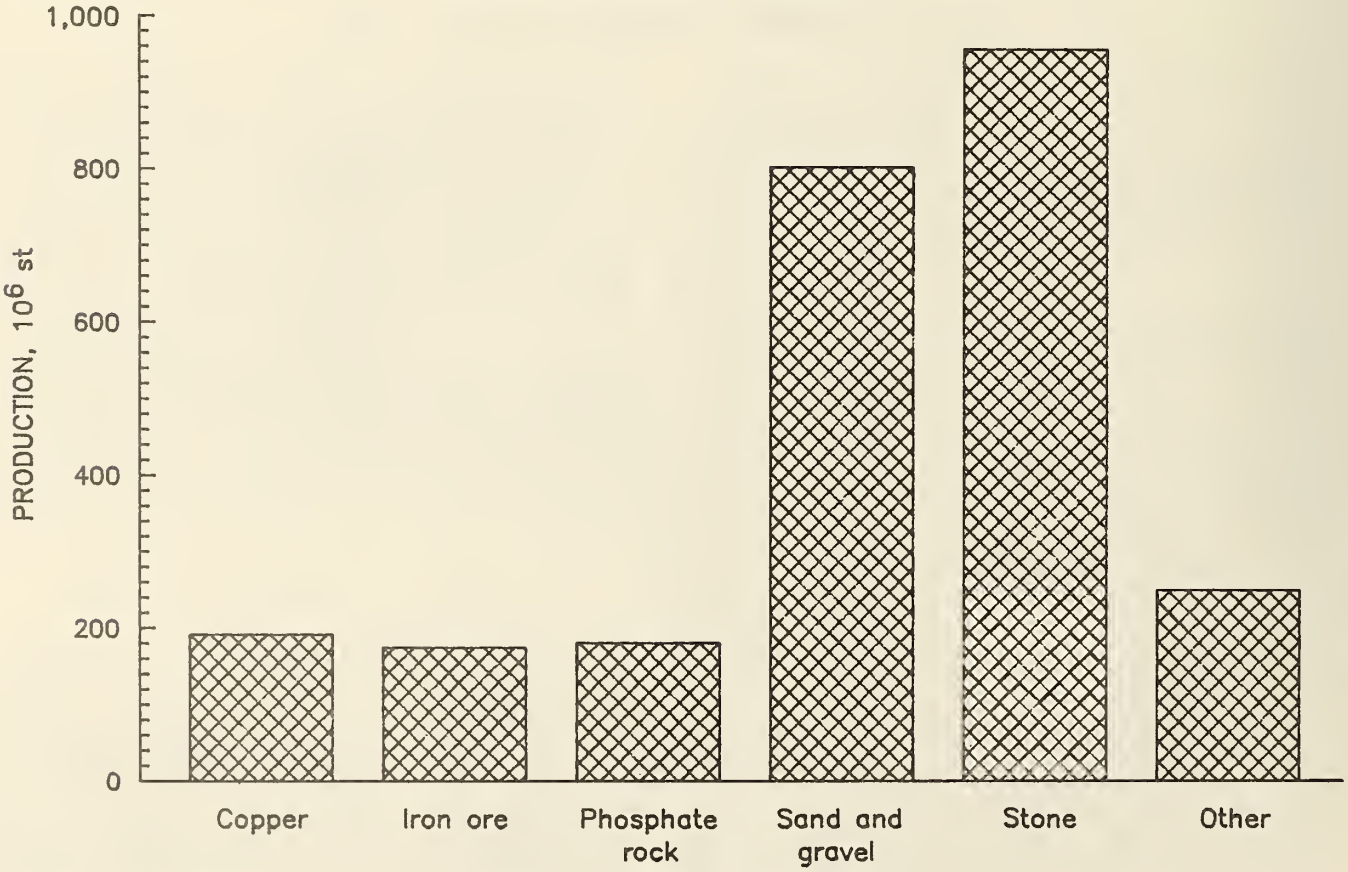

Figure 8.—Crude ore production, 1984.

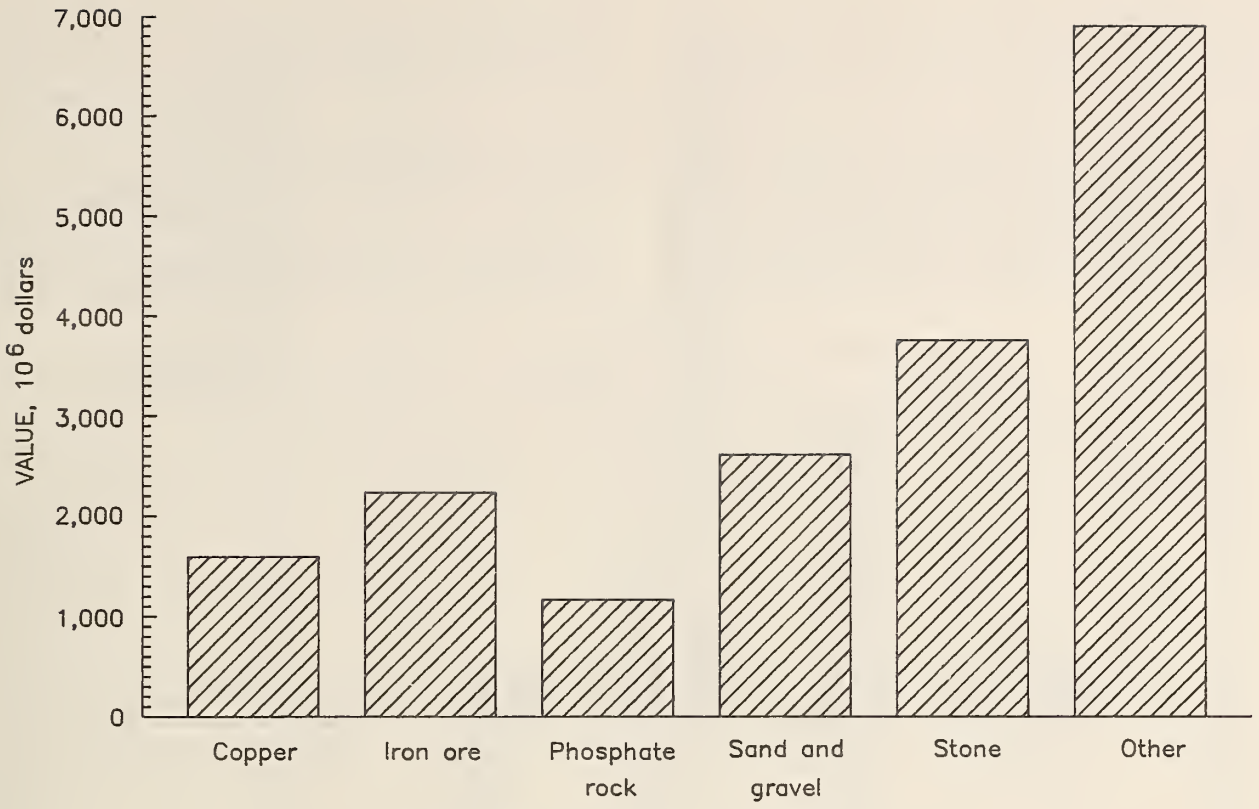

Figure 9.—Value of mine production, 1984.

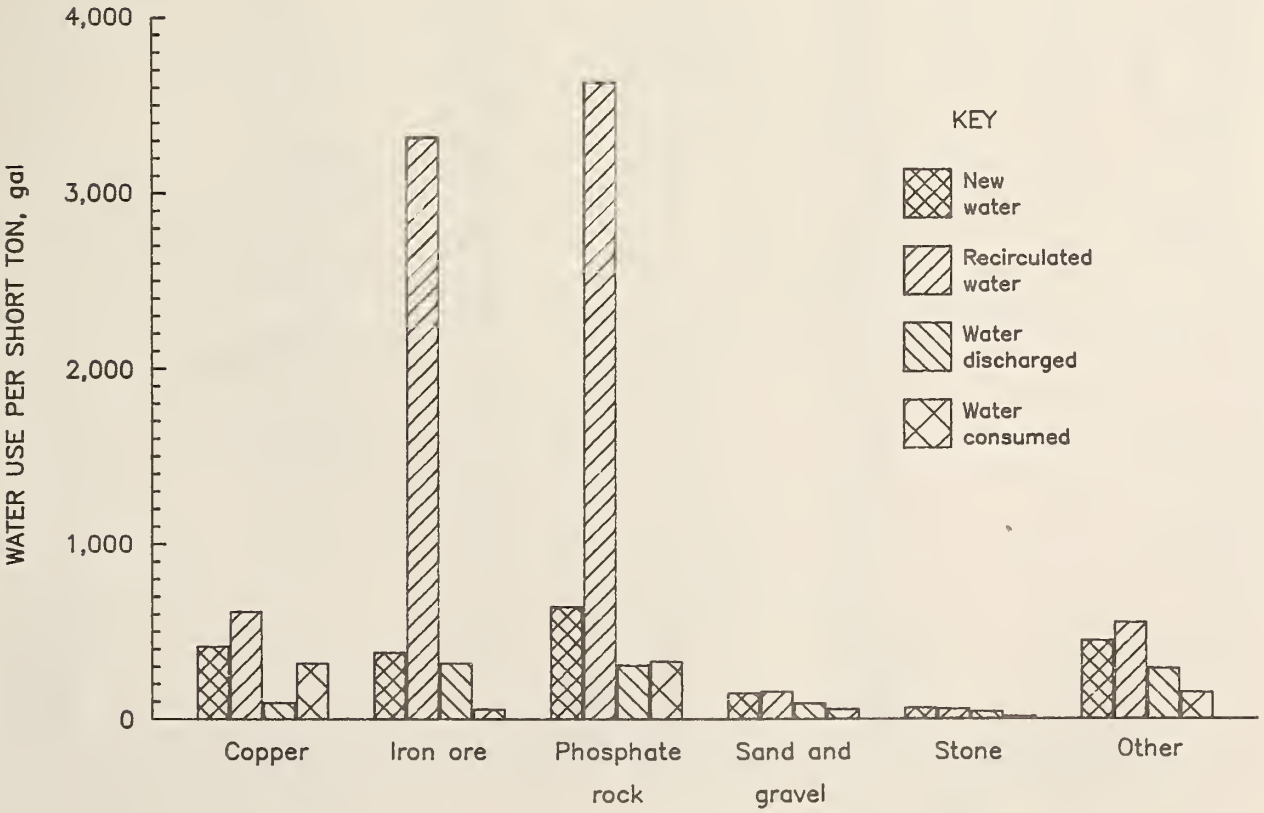

Figure 10.—Water use per short ton of crude ore production, 1984.

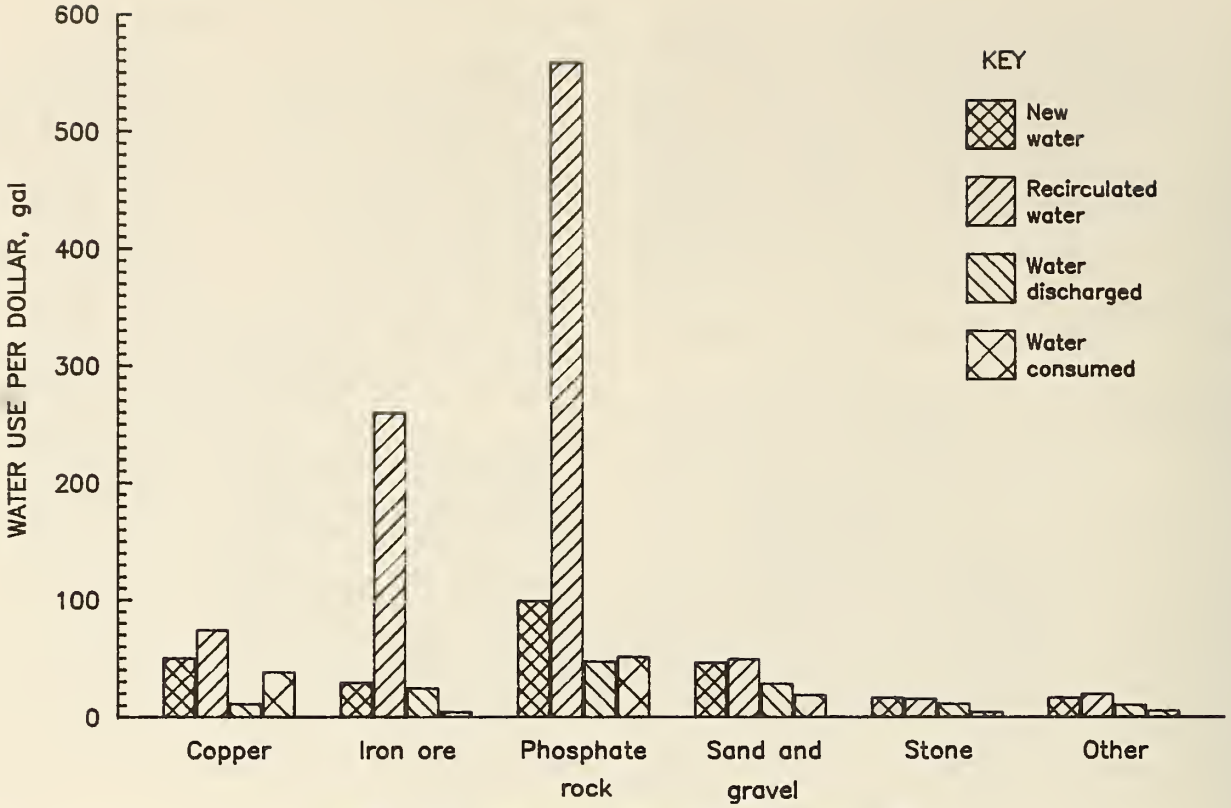

Figure 11.—Water use per dollar of mine production, 1984.

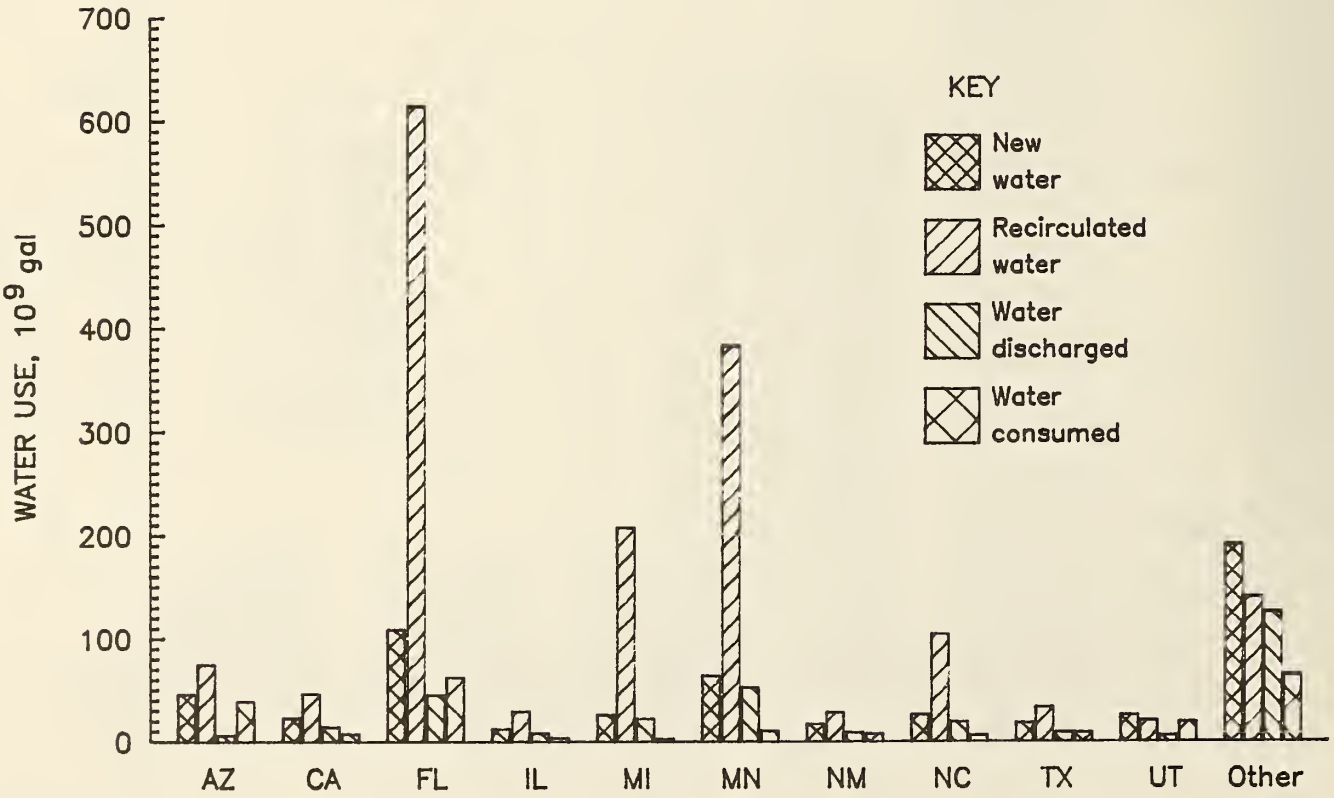

Figure 12.—Water use, by State, 1984.

phosphate rock production. The production of sand and gravel and sodium compounds used more than three-fourths of the water in California. Most of the water in Illinois and Texas was used in the production of crushed stone and sand and gravel.

The States that utilized the most water also accounted for most of the water recirculated. About 85% of the water used in Florida, 89% in Michigan, and 86% in Minnesota was recirculated.

States in the arid West consumed a substantial portion of their new water intake. These States included Arizona, Montana, Nevada, New Mexico, Texas, Utah, and Wyoming. In Arizona, water consumption amounted to almost 85% of new water intake, mostly in the production of copper.

Although new water withdrawals by the nonfuel minerals industry amounted to 571 billion gal during 1984, this amount was negligible relative to withdrawals by other end-use sectors. New water withdrawals for all end uses by individual States in 1980 were derived from Solley, Chase, and Mann (*7*), as shown in table 1. For the same end uses, new water withdrawals by these States in

Table 1.—Population and new water withdrawals, by State, 1980 and 1984

State	1980[1]		1984			
	Population, 10^3 persons	Total withdrawals, 10^9 gal	Population, 10^3 persons	Total withdrawals, 10^9 gal	Nonfuel withdrawals	
					10^9 gal	% of total
Alabama	3,890	4,015	3,989	4,117	5.4	0.13
Alaska	403	80	505	100	6.3	6.30
Arizona	2,718	2,920	3,072	3,300	47.4	1.44
Arkansas	2,920	5,840	2,346	5,983	1.9	.03
California	23,669	19,710	25,795	21,480	24.0	.11
Colorado	2,889	5,840	3,190	6,448	4.4	.07
Connecticut	3,108	1,351	3,155	1,371	1.1	.08
Delaware	595	438	614	452	.3	.07
Florida	9.740	7,665	11,050	8,696	110.4	1.27
Georgia	5,464	2,519	5,842	2,693	22.7	.84
Guam[2]	NA	NA	NA	NA	.2	NAp
Hawaii	965	913	1,037	981	.8	.08
Idaho	944	6,570	999	6,953	2.4	.03
Illinois	11,418	6,570	11,522	6,630	13.6	.21
Indiana	5,396	5,110	5,492	5,201	3.7	.07
Iowa	2,913	1,570	2,903	1,564	2.7	.17
Kansas	2,363	2,409	2,440	2,487	7.3	.29
Kentucky	3,661	1,752	3,720	1,780	1.9	.11
Louisiana	4,199	4,745	4,461	5,041	12.5	.25
Maine	1,125	584	1,156	600	1.0	.17
Maryland	4,216	2,811	4,349	2,899	2.4	.08
Massachusetts	5,737	2,154	5,798	2,176	2.5	.11
Michigan	9,258	5,475	9,058	5,357	26.9	.50
Minnesota	4,061	1,132	4,163	1,160	65.0	5.60
Mississippi	2,521	1,278	2,598	1,317	2.0	.15
Missouri	4,888	2,519	5,001	2,577	7.6	.29
Montana	786	4,015	823	4,204	2.7	.06
Nebraska	1,570	4,380	1,605	4,478	1.6	.04
Nevada	79	1,314	917	1,508	10.5	.70
New Hampshire	921	365	978	388	.7	.18
New Jersey	7,360	3,650	7,517	3,728	8.7	.23
New Mexico	1,300	1,424	1,426	1,562	18.3	1.17
New York	17,557	6,205	17,746	6,272	18.2	.29
North Carolina	5,874	2,957	6,166	3,104	27.3	.88
North Dakota	652	475	687	500	.8	.16
Ohio	10,797	5,110	10,740	5,083	9.2	.18
Oklahoma	3.025	657	3,310	719	1.6	.22
Oregon	2,614	2,482	2,676	2,541	1.7	.07
Pennsylvania	11,824	5,840	11,887	5,871	11.2	.19
Puerto Rico[2]	3,400	1,168	3,269	1,123	.1	.01
Rhode Island	947	183	962	185	.2	.11
South Carolina	3,119	2,263	3,302	2,396	2.7	.11
South Dakota	695	252	705	255	.8	.31
Tennessee	4,591	3,650	4,726	3,757	15.0	.40
Texas	14,013	7,665	16,083	8,797	19.3	.22
Utah	1,462	1,679	1,623	1,864	26.7	1.43
Vermont	511	124	530	128	.5	.39
Virgin Islands[2]	100	14	110	15	.0	.00
Virginia	5,346	3,541	5,636	3,733	2.3	.06
Washington	4,127	3,030	4,349	3,192	3.6	.11
West Virginia	1,950	2,044	1,952	2,046	1.3	.06
Wisconsin	4,710	2,117	4,762	2,140	2.8	.13
Wyoming	471	1,971	511	2,138	7.0	.33
Total or average	228,952	164,669	239,253	173,090	571.2	.33

NA Not available. NAp Not applicable.
[1] Solley, Chase, and Mann (*7*).
[2] U.S.-administered islands and commonwealth.

1984 were estimated from the observed change in population. For example, the population in Alabama increased by about 2.5% from 1980 to 1984; it could then be assumed that new water withdrawals in Alabama increased by the same proportion during this period. A comparison of new water withdrawals by the nonfuel minerals industry with total new water withdrawals in each State during 1984 seems to indicate that in all cases new water requirements for the mineral sector were insignificant. On the whole, more than 80% of all new water withdrawals by all States was used in irrigation and thermoelectric power generation (table 2). The data in table 2 were derived on the assumption that end-use patterns in individual States in 1984 remained unchanged from 1980.

WATER USE, BY STATE AND TYPE OF OPERATION

About 80% of all water used by the nonfuel minerals industry in Florida was in processing phosphate rock (fig. 13). Phosphate rock mining accounted for only 9% of

Table 2.—New water use, by State and major end-use sectors, 1984, billion gallons

State	Public supply	Rural uses	Irrigation	Thermo-electricity	Industrial uses[1]	Total
Alabama	238	72	13	3,294	500	4,117
Alaska	24	.5	0	13	58	100
Arizona	232	18	2,947	37	66	3,300
Arkansas	99	45	1,945	3,699	195	5,983
California	1,636	91	14,768	4,470	515	21,480
Colorado	242	85	5,751	70	300	6,448
Connecticut	133	20	8	1,110	100	1,371
Delaware	29	10	2	255	156	452
Florida	568	125	1,216	6,447	340	8,696
Georgia	300	66	226	1,780	321	2,693
Guam[2]	NA	NA	NA	NA	NA	NA
Hawaii	78	4	355	523	21	981
Idaho	60	26	6,035	2	830	6,953
Illinois	667	54	41	5,187	681	6,630
Indiana	219	61	87	3,663	1,171	5,201
Iowa	113	67	20	1,164	200	1,564
Kansas	110	55	2,122	133	67	2,487
Kentucky	128	36	2	1,497	117	1,780
Louisiana	242	29	874	2,415	1,481	5,041
Maine	39	11	2	292	256	600
Maryland	184	23	8	2,441	243	2,889
Massachusetts	294	12	7	1,726	137	2,176
Michigan	440	62	71	4,065	719	5,357
Minnesota	166	71	60	641	222	1,160
Mississippi	108	18	366	597	228	1,317
Missouri	276	59	49	2,079	114	2,577
Montana	51	32	4,014	66	41	4,204
Nebraska	97	63	3,472	821	25	4,478
Nevada	96	10	1,300	39	63	1,508
New Hampshire	34	4	1	268	81	388
New Jersey	395	28	20	2,658	627	3,728
New Mexico	83	21	1,397	26	35	1,562
New York	833	71	17	4,885	466	6,272
North Carolina	218	68	50	1,646	1,122	3,104
North Dakota	23	12	107	355	3	500
Ohio	526	48	2	3,756	751	5,083
Oklahoma	119	37	346	72	145	719
Oregon	86	65	2,196	8	186	2,541
Pennsylvania	566	80	60	3,807	1,358	5,871
Puerto Rico[2]	121	12	107	520	363	1,123
Rhode Island	48	2	2	121	12	185
South Carolina	136	34	21	2,016	189	2,396
South Dakota	28	42	167	2	16	255
Tennessee	190	32	4	2,899	632	3,757
Texas	1,598	168	3,532	2,729	770	8,797
Utah	304	28	1,296	28	208	1,864
Vermont	18	11	1	93	5	128
Virgin Islands[2]	2	1	0	12	0	15
Virginia	232	69	11	3,208	213	3,733
Washington	311	22	2,461	1	397	3,192
West Virginia	65	10	1	1,669	301	2,046
Wisconsin	212	55	32	1,674	167	2,140
Wyoming	32	10	1,933	87	76	2,138
Total	13,049	2,160	59,525	81,066	17,290	173,090

NA Not available.
[1]Including mining and minerals processing.
[2]U.S.-administered islands and commonwealth.

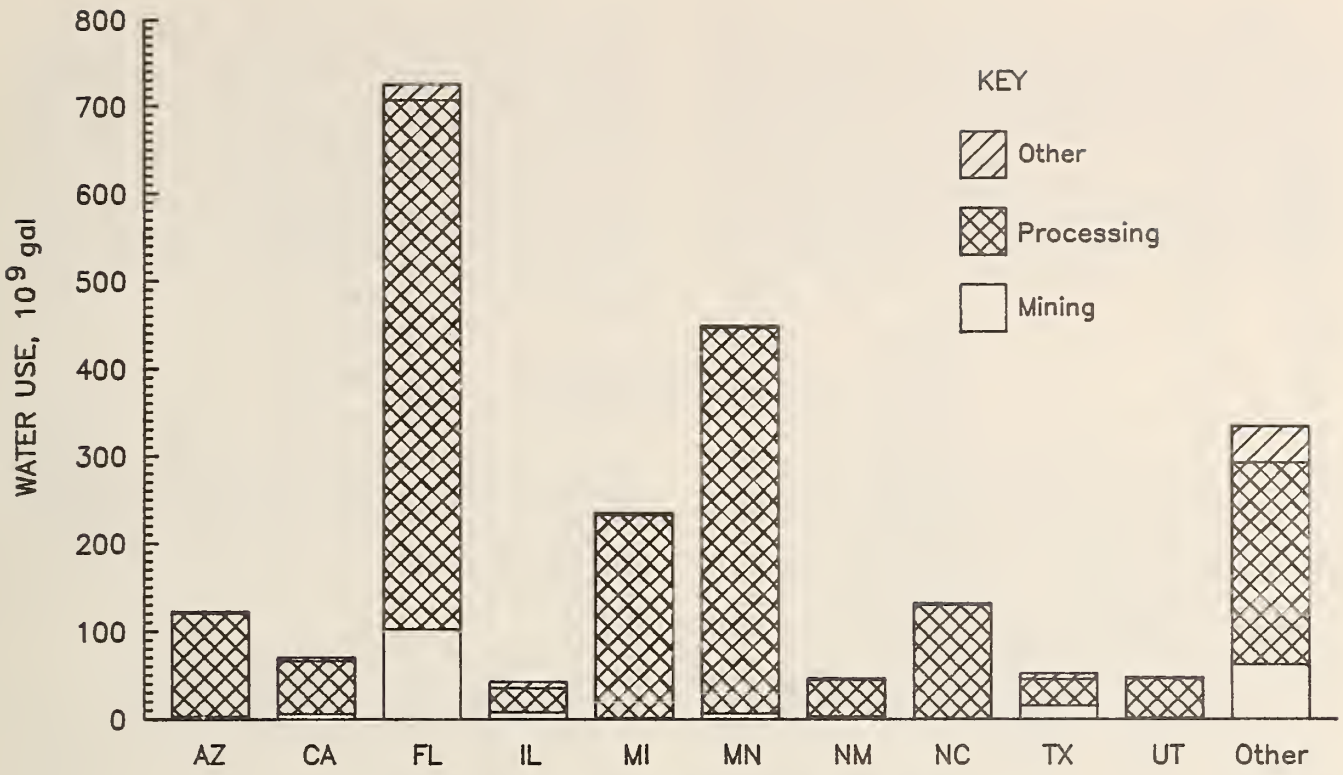

Figure 13.—Water use, by State and type of operation, 1984.

total use in that State. In Michigan and Minnesota, practically all of the water was used in processing iron ore. Similarly, processing of copper ore was the major use of water in Arizona, New Mexico, and Utah. And in California, Illinois, North Carolina, and Texas, the major use of water was in processing crushed stone, phosphate rock, sand and gravel, and sodium compounds.

SOURCES OF NEW WATER, BY STATE

The largest users of ground water were, in decreasing order of quantity, Florida, Arizona, North Carolina, Utah, and Georgia, together accounting for about 72% of all ground water used (fig. 14). Ground water sources represented 61% of the new water intake in Arizona, 49% in Florida, 71% in Georgia, 87% in North Carolina, and 88% in Utah.

Florida was also the largest user of mine water, followed by Minnesota, New Mexico, California, Pennsylvania, and Texas. Together, these States accounted for 51% of all mine water used. Mine water represented 28% of the new water intake in California, 11% in Florida, 17% in Minnesota, 47% in New Mexico, 58% in Pennsylvania, and 21% in Texas.

In contrast, Tennessee was the largest user of stream and river water, followed by Michigan, Arizona, Illinois, and Louisiana. Together, they accounted for 50% of all stream and river water used. This source of water provided 21% of the new water intake in Arizona, 55% in Illinois, 54% in Louisiana, 43% in Michigan, and 80% in Tennessee.

Nearly one-half of all lake and reservoir water used was in Minnesota. The next largest users of lake and reservoir water were Michigan, New York, and New Jersey, together accounting for 26% of total. This source of water provided 42% of new water intake in Michigan, 79% in Minnesota, 82% in New Jersey, and 59% in New York.

Almost 67% of all water derived from miscellaneous sources was used in Florida. While some of this water was from public water systems, most of the remainder was from unspecified sources.

WATER TREATMENT, BY STATE

Treatment of water prior to use, recirculation, or discharge in individual States is largely a reflection of the pattern of usage and the quality of water being used or discharged. By and large, States using the most water for mining or processing are likely to treat large amounts of this water prior to use. Similarly, States with stringent quality standards for wastewater are likely to treat mine or plant effluents prior to discharge into the environment.

During 1984, the three largest users—Florida, Michigan, and Minnesota—treated 96%, 98%, and 66%, respectively, of their recirculated water prior to use in processing phosphate rock and iron ore (fig. 15). About 41% of the new water in Florida, 24% in Michigan, and 9% in Minnesota was treated prior to use. The lower percentage for new water treated in Minnesota was probably a reflection of the relatively large amount of good quality intake from lakes and reservoirs. More than 87% of all water discharged in Florida and 65% in Michigan was treated, presumably to comply with State and local water quality standards. Only 19% of discharge water in Minnesota was treated.

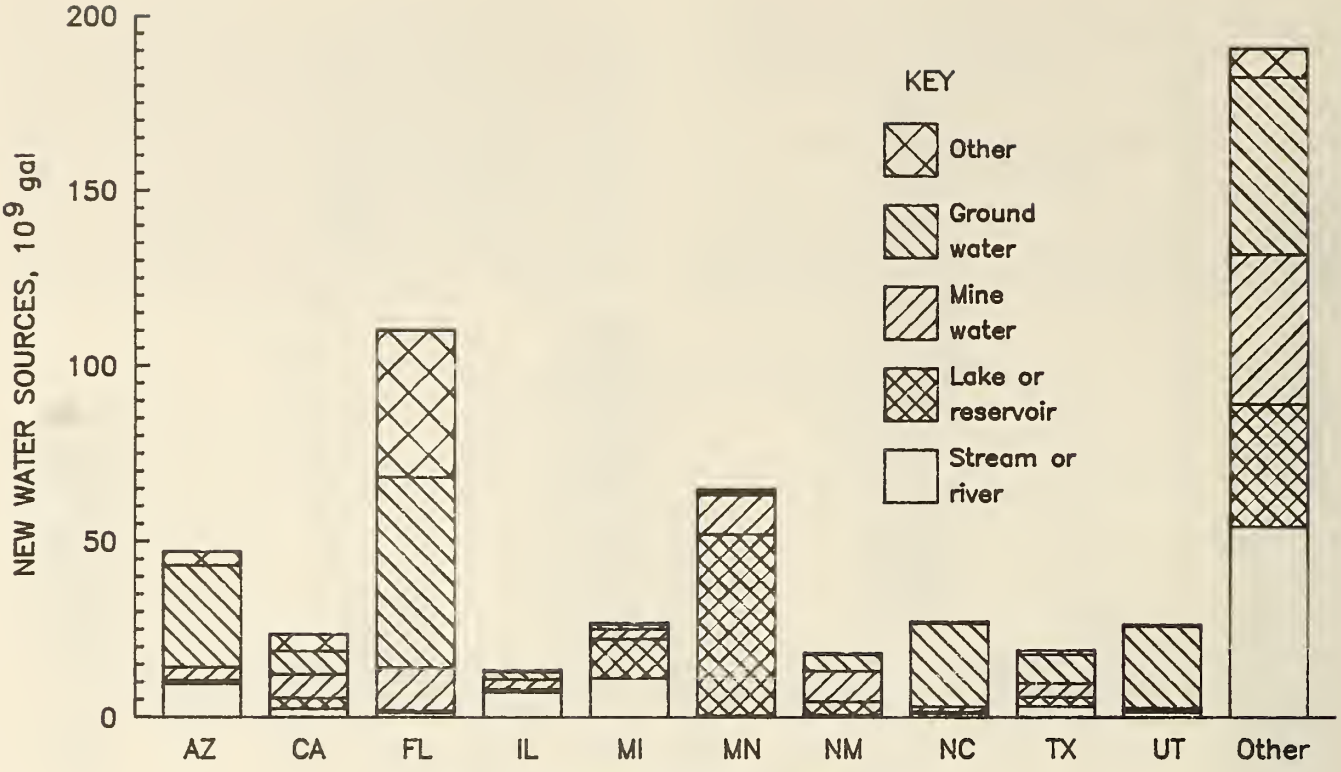

Figure 14.—Sources of new water, by State, 1984.

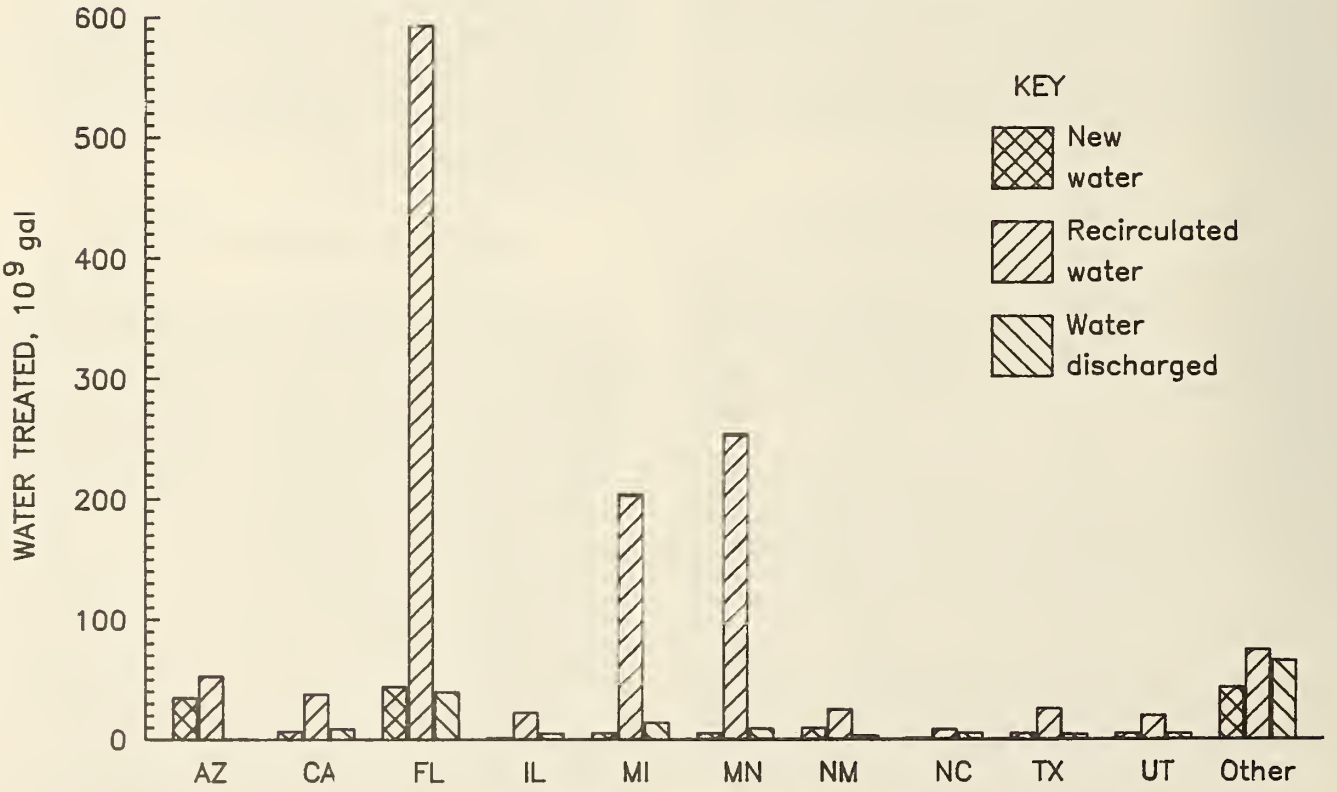

Figure 15.—Types of water treated, by State, 1984.

In the copper industry of Arizona, 76% of its new water, 71% of its recirculated water, and a minor amount of its discharge water was treated. New Mexico's copper industry treated 61% of its new water intake, 90% of its recirculated water, and 42% of its discharge water. In Utah, the copper industry treated only 23% of its new water but most of its recirculated and discharge water.

Other States with substantial amounts of water treatment included California, Louisiana, New Jersey, and Texas. Thirty-four percent of new water, 82% of recirculated water, and 66% of discharge water were treated prior to use or discharge in California. In Louisiana, 51% of new water, 10% of recirculated water, and 61% of discharge water were treated. In Texas, 52% of discharge water was treated, compared with 77% of new water and 30% of recirculated water.

Although a large amount of water was used in North Carolina, only 7% of its new water, 9% of its recirculated water, and 32% of its discharge water received some form of treatment prior to use or discharge.

WATER USE TRENDS

In order to examine trends in water utilization in the domestic nonfuel minerals industry, data from this canvass were combined with those from an earlier Bureau of Mines canvass (*12*) as well as with data from the Bureau of the Census (*8-11*). However, some comments on the completeness, comparability, and consistency of the available data should be noted.

Inasmuch as the data encompassed water use only for the years 1954, 1962, 1968, 1973, 1983, and 1984, they did not provide for an adequate or complete time series from which meaningful statistical inferences could be drawn.

The Bureau of the Census utilized a 10% sample of all metal and nonmetal mines in each of its canvasses. These mines each had a water intake exceeding 20 million gal and together accounted for about 95% of total estimated water use in the nonfuel minerals industry. In contrast, the earlier of the two Bureau of Mines canvasses covered all mines known to have been in production during 1962, regardless of tonnage produced or water usage. In the Bureau's more recent canvass, mines were selected based solely on their crude ore production, regardless of their water usage. These differences in sampling procedure could possibly account for some of the observed incomparability in the water use data from one sample year to the next.

For all canvass years, the Bureau of the Census data on water discharge included water that was discharged during mine dewatering but not actually used in mining, processing, or related operations. As a result, the amount of water consumed in those years could not be correctly estimated, and no attempt has been made to examine trends in water consumption or water discharge.

For 1978, the sum of new water and recirculated water did not add to total water used in the Bureau of the Census data. Some minor subtractions from the amount of recirculated water were therefore made by the author to correct these discrepancies.

WATER USE TRENDS, BY COMMODITY

In the 25 yr since the first Bureau of Mines canvass, the mineral industry has undergone substantial change, in both the nature and scale of operations. Lower grade ores, such as in porphyry copper, have led to the mining and processing of larger tonnages, thus increasing the demand for water. Similarly, the depletion of direct-shipping iron ore in Minnesota resulted in the development of new technology for processing vast amounts of low-grade taconites. In recent times, there has been some increase in water usage in the solution mining of potash, the leaching of copper and gold, and the slurry transportation of phosphate rock. Also, State and local environmental regulations pertaining to discharge water quality have encouraged greater recycling as an economic alternative to water treatment prior to discharge. In some localities where water is scarce and subject to competing demands, there is an added incentive for mine operators to adopt recycling as a means of conserving water. Singly or in combination, all of these factors can be said to have governed water use patterns in the nonfuel minerals industry over the past 25 yr, and they will no doubt continue to do so into the future.

Over the period 1954-84, production of copper, iron ore, phosphate rock, sand and gravel, and stone together accounted for 73% to 90% of total water use, 89% to 92% of crude ore produced, and 62% to 72% of the value of mine production. While several metals and nonmetals, such as gold and silver, lead and zinc, clays, and potash and sodium carbonate, also had large values of mine production, their water usage and crude ore tonnage were relatively insignificant. Hence, the discussion that follows will focus largely on copper, iron ore, phosphate rock, sand and gravel, and stone.

Copper

Total water use in copper mines rose from 83 billion gal in 1954 to 496 billion gal in 1973, after which it fell to 202 billion gal in 1984 (fig. 16). This trend in water use roughly paralleled the growth and decline in crude ore production and mine value (fig. 17). The amount of water recirculated increased from 29% of total water use in 1954 to 80% in 1978 before declining to about 60% in 1984.

Water use per short ton of crude ore appeared to peak at 2,570 gal in 1968, followed by a steady decline to some 1,040 gal in 1984 (fig. 18). While water use per dollar of mine production also peaked in 1968, its decline thereafter was somewhat more erratic (fig. 19). Between 1978 and 1984, water use per dollar ranged from 122 to 131 gal.

Iron Ore

Total water use reached its maximum (849 billion gal) in 1973 (fig. 20), although iron ore production and value in 1978 were higher than in 1973 (fig. 21). For the most part,

however, water use rose and fell with crude ore production and mine value. From 1954 to 1978, the amount of water recirculated was between 48% and 58% of total water use, but in 1983 and 1984 it increased to about 90%, most likely because of successful implementation of water conservation practices during these 2 yr.

After reaching a peak of 3,480 gal in 1973, water use per short ton of crude ore fell to 2,860 gal in 1978, followed by a gradual increase to 3,700 gal in 1984 (fig. 22). The same general trend was also apparent in water use per dollar of mine production (fig. 23).

Phosphate Rock

Total water use in phosphate rock production (fig. 24) appeared to rise and fall with crude ore production and value during 1954-73 (fig. 25). In 1978 water use actually fell even when production and value increased, while in 1983 it increased in the face of declining production and value. Finally, it rose once again with rising production and value, and attained its maximum level of 780 billion gal in 1984. Between 1954 and 1978, recirculated water accounted for about 52% to 72% of total water use, but this ratio increased to over 85% in 1983 and 1984, offsetting the net decline in new water use in these years. The significant increase in 1983-84 could be ascribed to successful conservation practices implemented by the industry during those years.

Water use per short ton of crude ore attained its maximum of 6,110 gal in 1962, after which it declined to its minimum of 1,900 gal in 1978 (fig. 26). From 1978 to 1984 water use per short ton appeared to increase steadily once again, reaching 4,280 gal in 1984. Water use per dollar of production reached its highest level of 860 gal in 1973, fell to its lowest level of 260 gal in 1978, and rose steadily thereafter to 660 gal in 1984 (fig. 27).

Sand And Gravel

Total water use in sand and gravel operations rose from 260 billion gal in 1954 to 340 billion gal in 1962 (fig. 28); it then fell to 178 billion gal in 1968 even as production and value were increasing (fig. 29). From 1968 through 1984, water use rose and fell with production and value. In contrast to copper, iron ore, and phosphate rock production, new water use in sand and gravel production appeared to exceed recirculated water use for most years.

Water use per short ton of crude ore fell from 470 gal in 1954 to 220 gal in 1968, after which it gradually increased to 320 gallons in 1984 (fig. 30). The same general trend could also be observed for water use per dollar of production (fig. 31).

Stone

For the most part, total water use in stone production (fig. 32) generally increased and decreased with production and value (fig. 33), with the largest increase in 1984 seemingly anomalous. As with sand and gravel, new water use in stone operations appeared to exceed recirculated water use for most years.

Water use per short ton of crude ore steadily decreased from 150 gal in 1954 to 60 gal in 1973, after which it increased steadily to 130 gal in 1984 (fig. 34). Water use per dollar of production also followed a similar trend (fig. 35).

All Nonfuel Minerals

For the most part, total water use in the nonfuel minerals industry (fig. 36) roughly paralleled crude ore production and mine value (fig. 37). However, new water intake steadily fell from 61% of total water use in 1954 to 25% in 1984, clearly indicating a decline in its importance relative to recirculated water in the nonfuel minerals industry.

New water withdrawals in billion gallons per day and per year for all offstream uses in the United States during the period 1950-80 were estimated by Solley, Chase, and Mann (*7*) as shown in table 3. Interpolating between years and comparing with new water intake in the nonfuel minerals industry, it could be seen that uses of water in the nonfuel minerals sector accounted for less than 1% of water withdrawn for all offstream uses, and this ratio had been declining steadily since 1968 (table 4).

Table 3.—New water withdrawals for all U.S. offstream uses (*7*), billion gallons

Year	Per day	Per year
1950	180	66,000
1955	240	88,000
1960	270	99,000
1965	310	113,000
1970	370	135,000
1975	420	153,000
1980	450	164,000

Table 4.—Mineral sector use of water

Year	Use, 10^9 gal		Mineral sector use, %
	All	Mineral sector	
1954	84,000	507	0.6
1962	105,000	758	.7
1968	125,000	982	.8
1973	146,000	956	.7
1978	160,000	855	.5
1983	170,000	548	.3
1984	173,000	571	.3

Water use per short ton of nonfuel minerals production rose from about 720 gal in 1962 (data for 1954 not available) to 870 gal in 1968 and then fell to 720 gal in 1973, after which it steadily rose to 890 gal in 1984 (fig. 38). Water use per dollar of mine production increased sharply from 60 gal in 1954 to 110 gal in 1962 and then declined to about 100 gal in 1978, after which it increased once again to over 120 gal in 1984 (fig. 39).

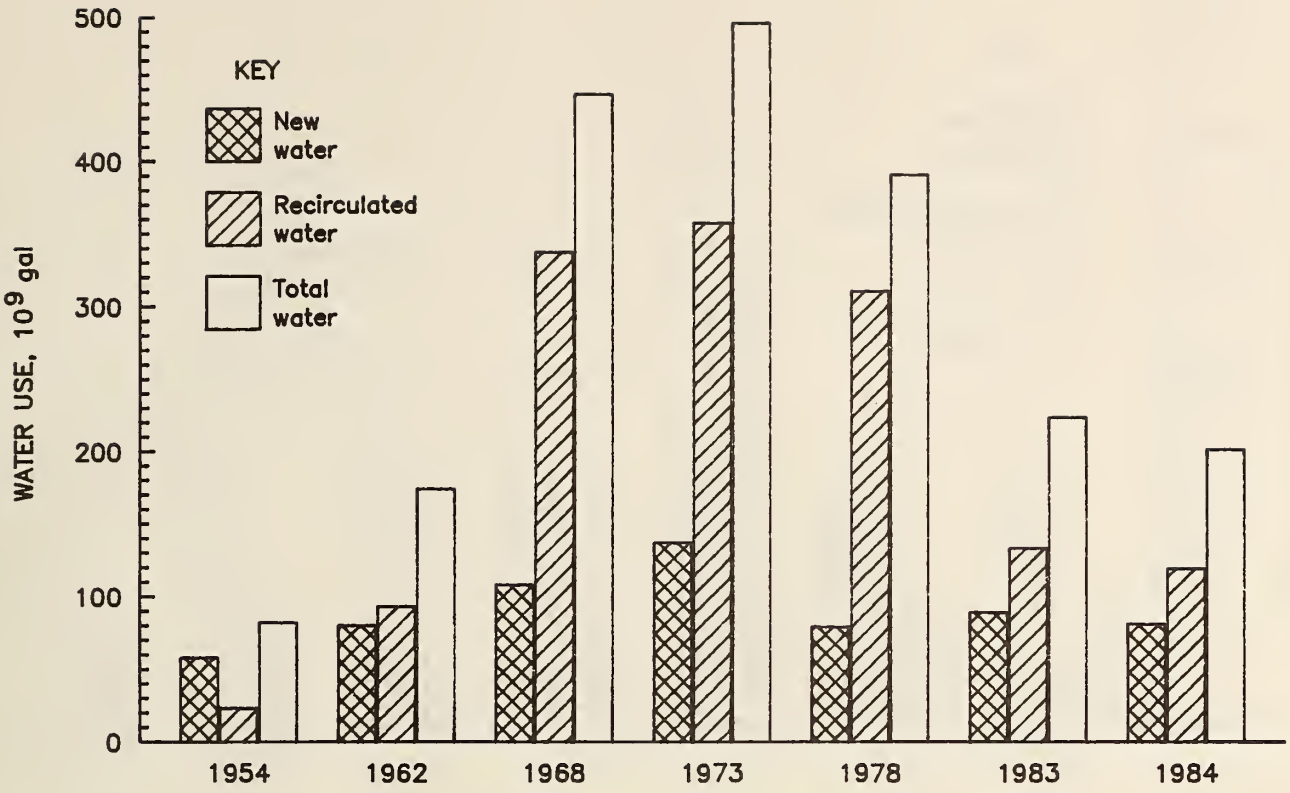

Figure 16.—Copper industry water use, 1954-84.

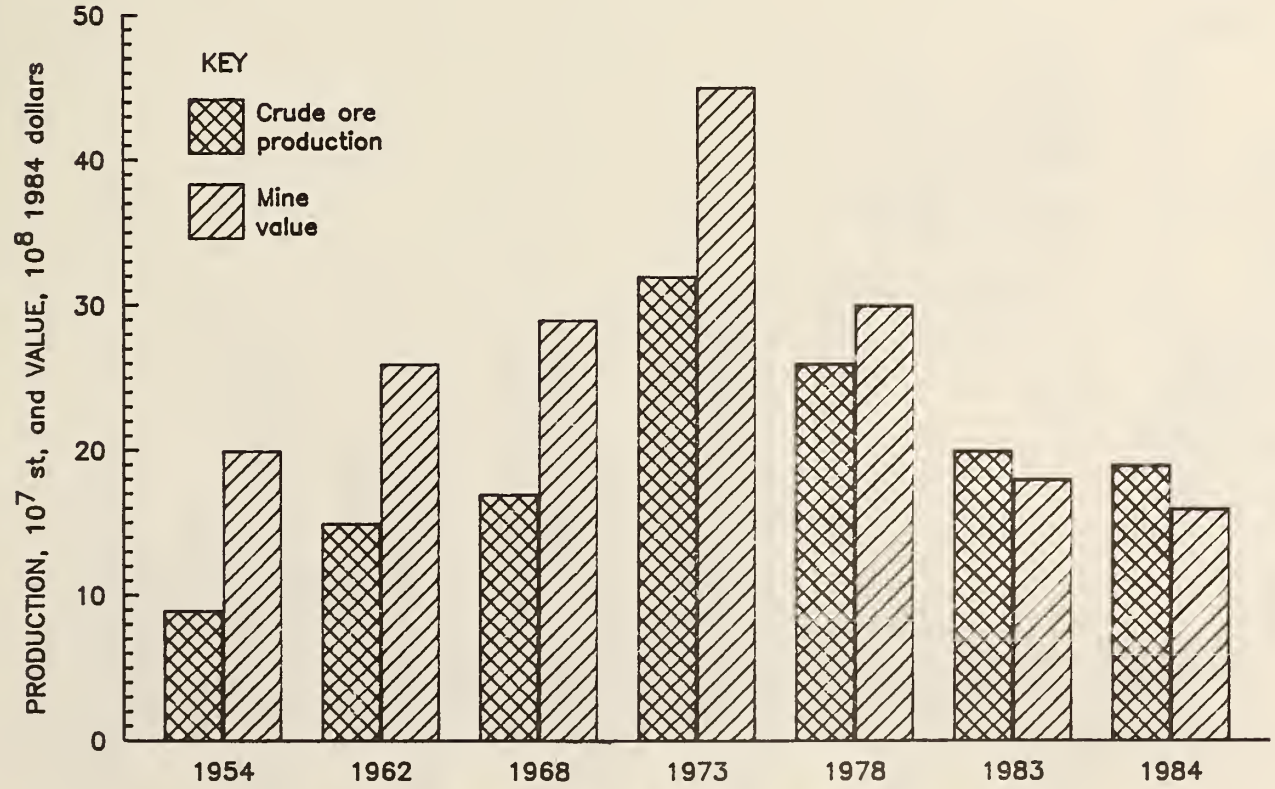

Figure 17.—Copper industry crude ore production and mine value, 1954-84.

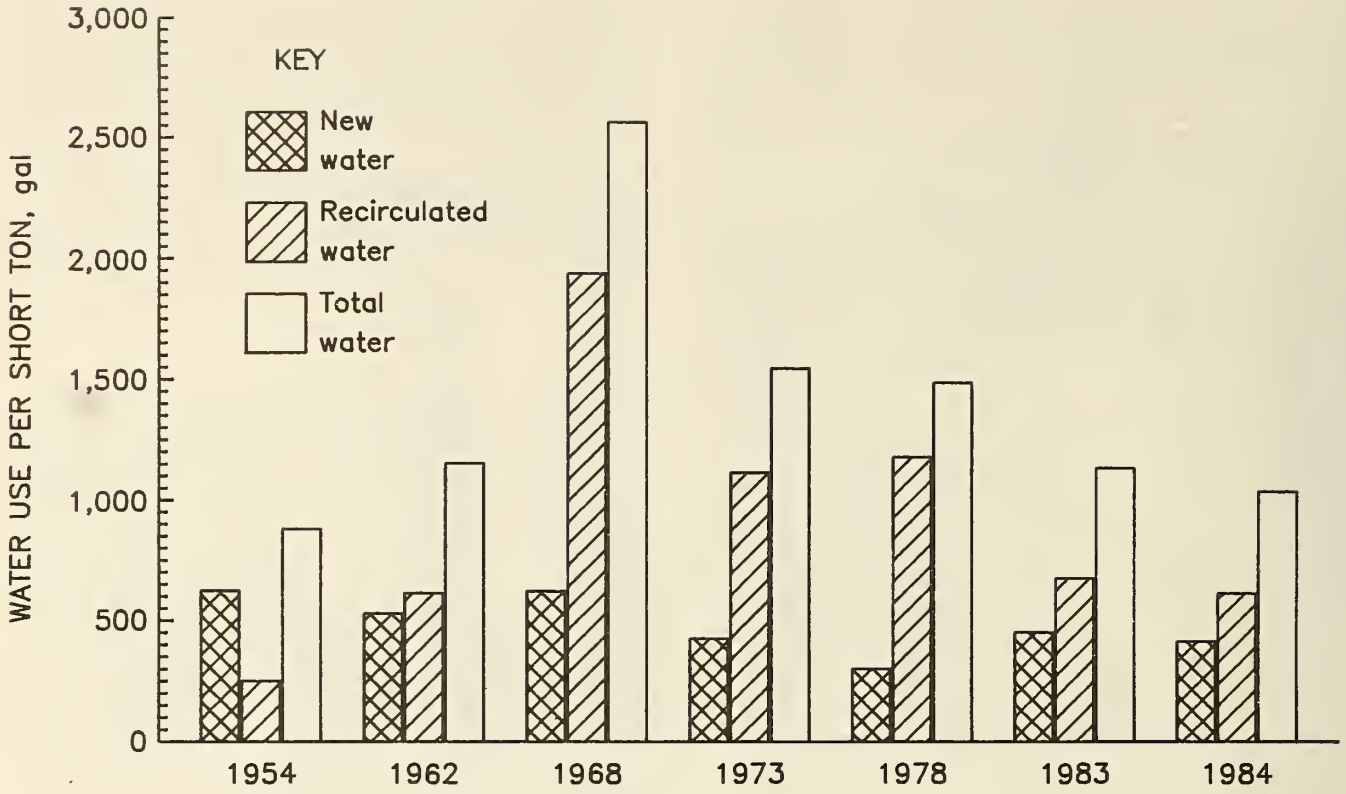

Figure 18.—Copper industry water use per short ton of crude ore production, 1954-84.

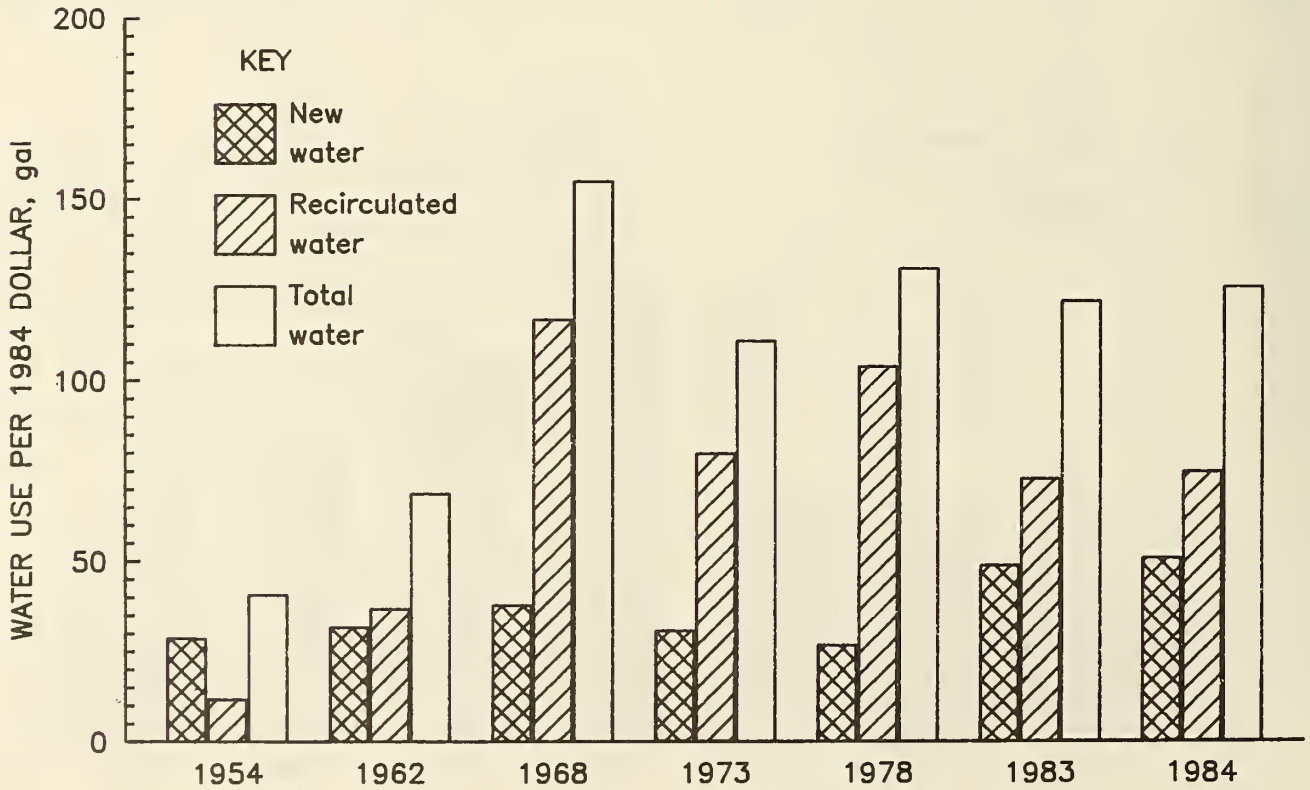

Figure 19.—Copper industry water use per 1984 dollar of mine production, 1954-84.

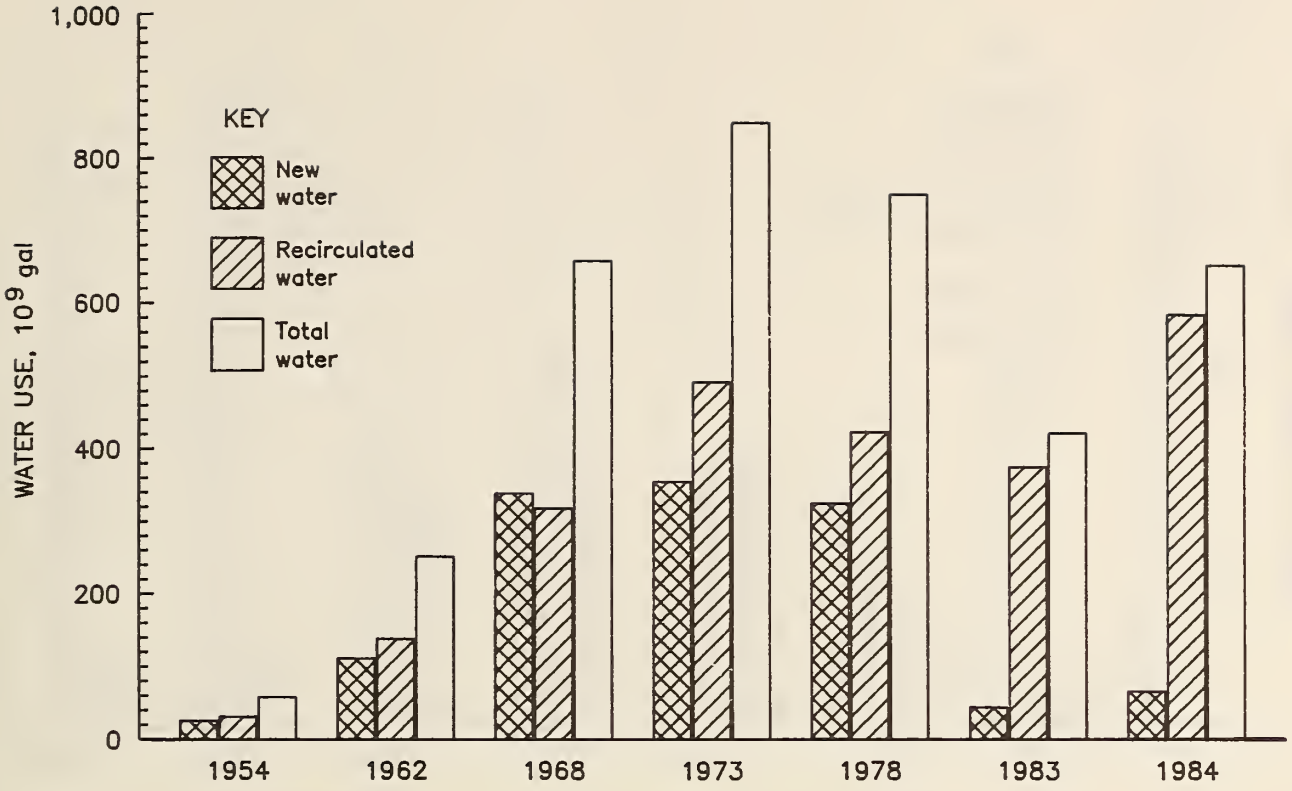

Figure 20.—Iron ore industry water use, 1954-84.

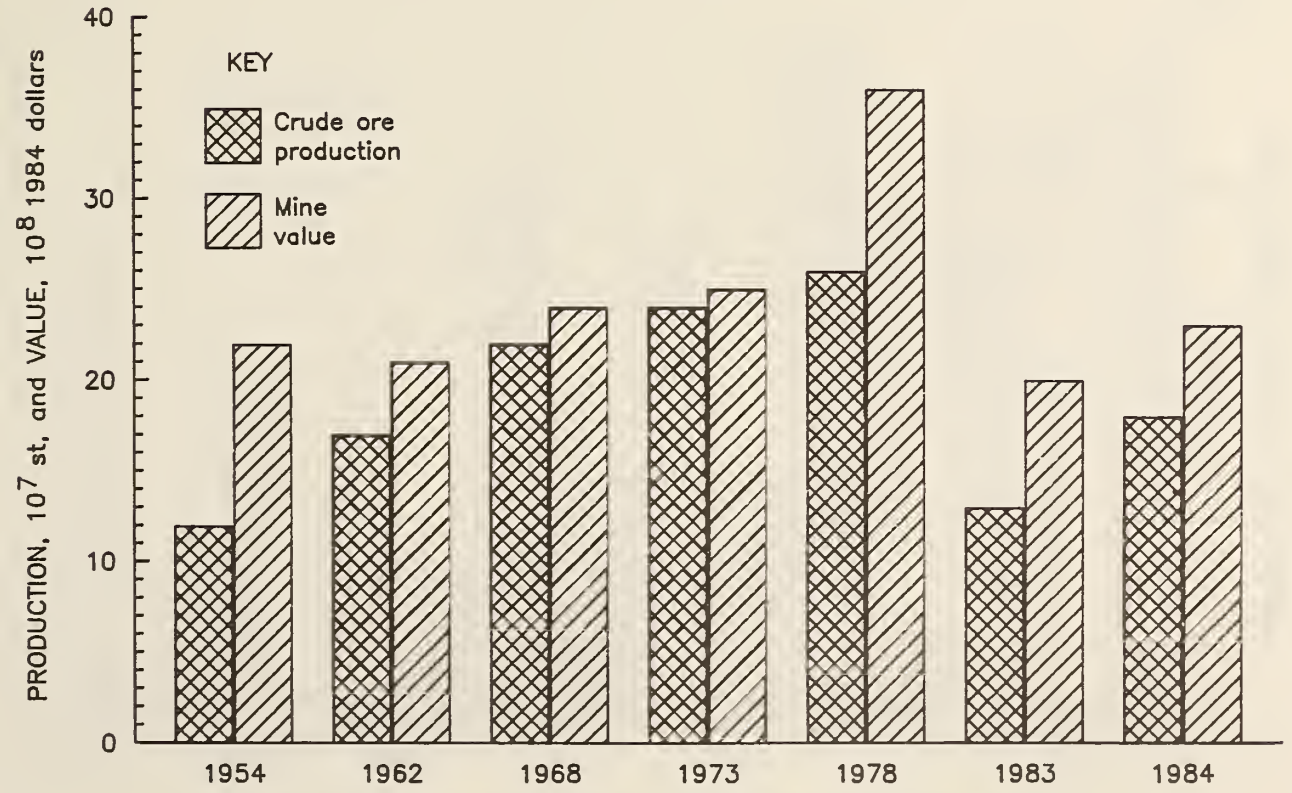

Figure 21.—Iron ore industry crude ore production and mine value, 1954-84.

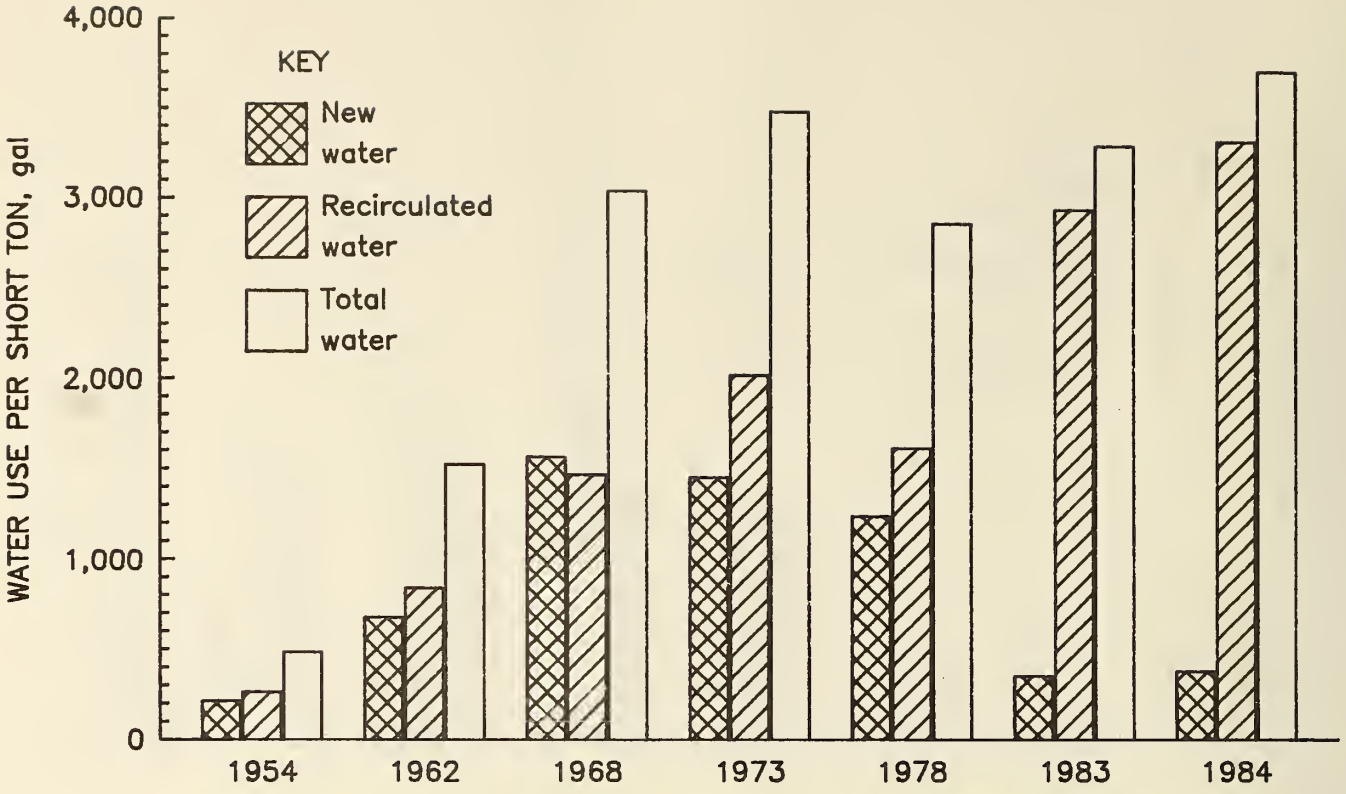

Figure 22.—Iron ore industry water use per short ton of crude ore production, 1954-84.

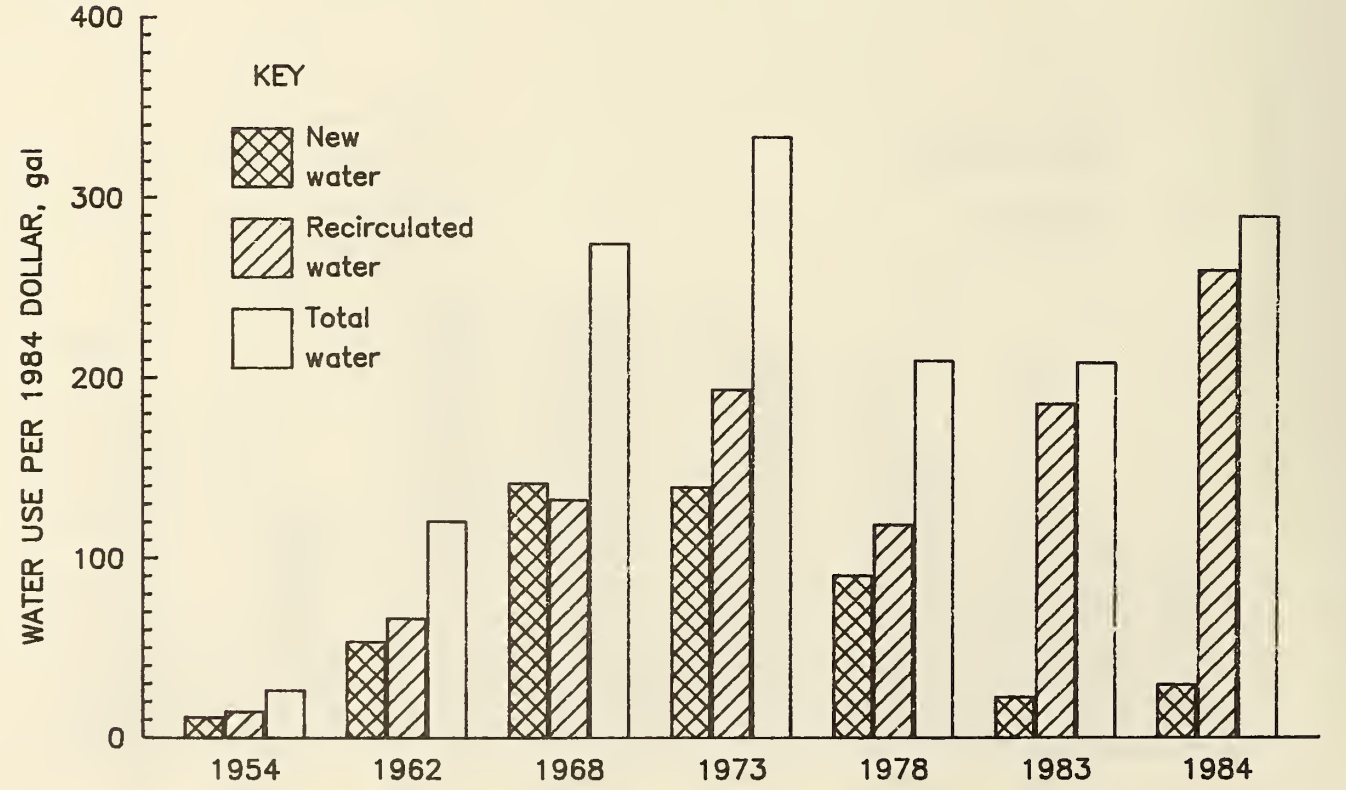

Figure 23.—Iron ore industry water use per 1984 dollar of mine production, 1954-84.

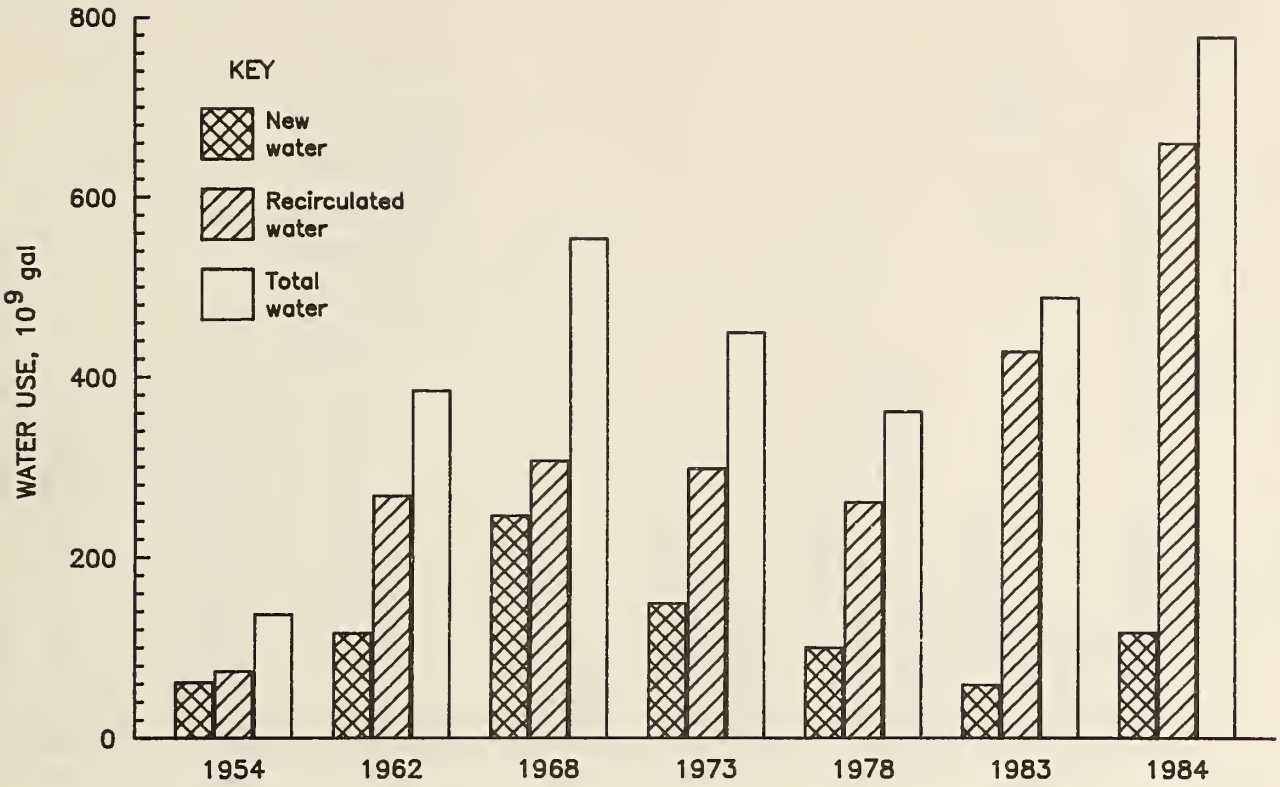

Figure 24.—Phosphate rock industry water use, 1954-84.

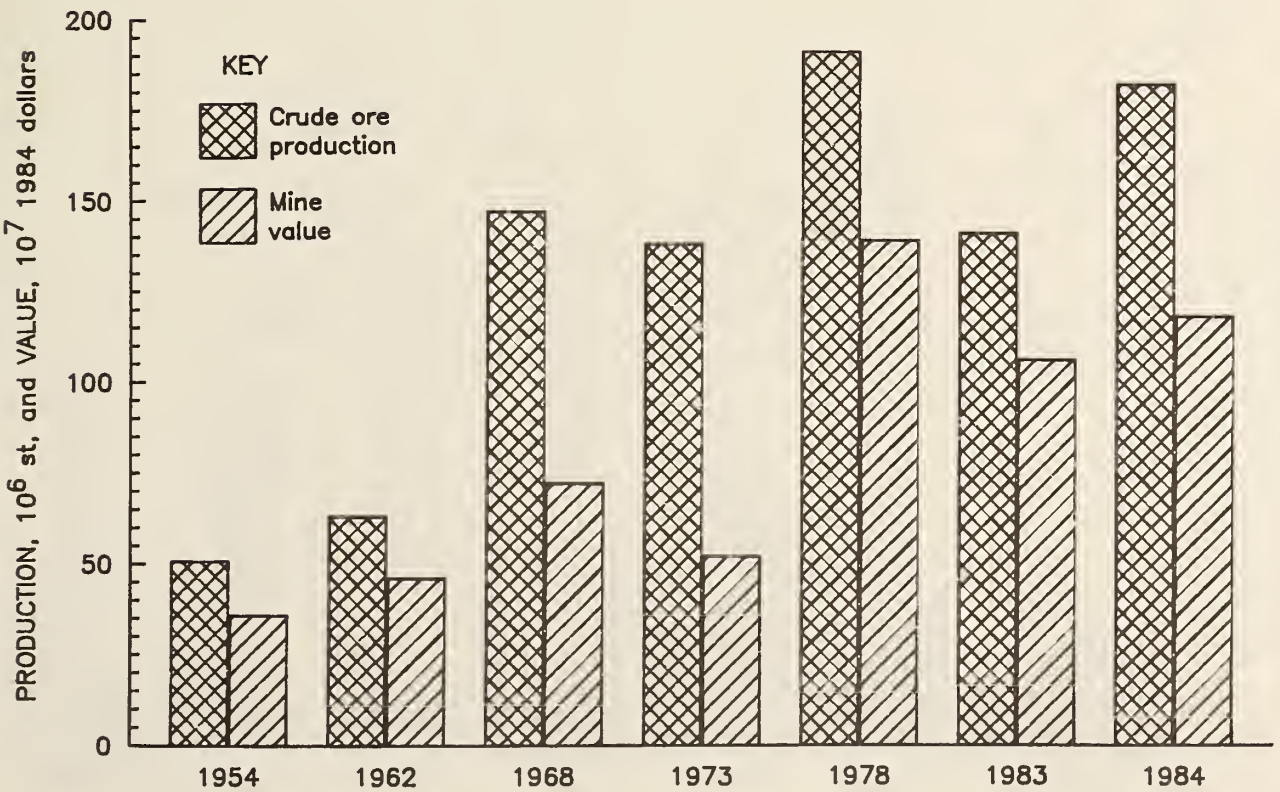

Figure 25.—Phosphate rock industry crude ore production and mine value, 1954-84.

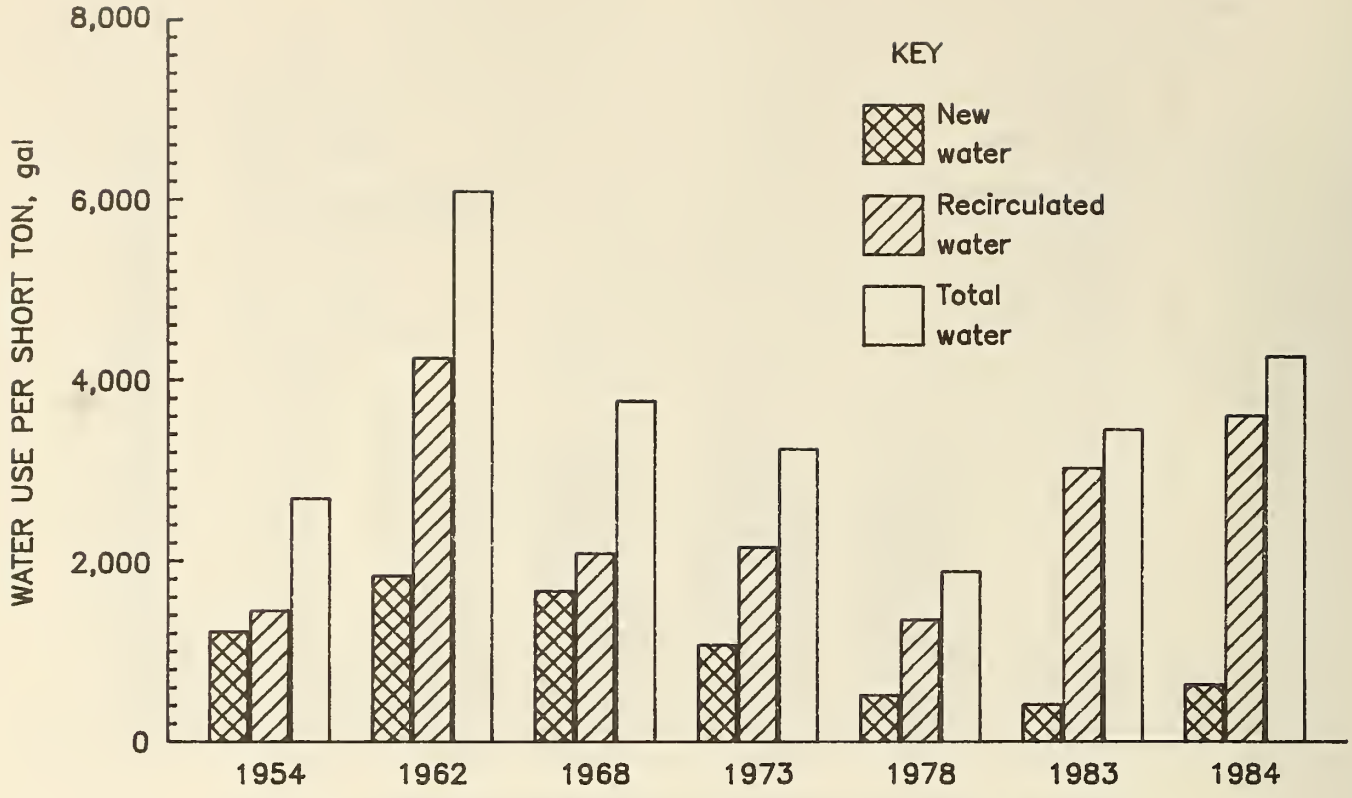

Figure 26.—Phosphate rock industry water use per short ton of crude ore production, 1954-84.

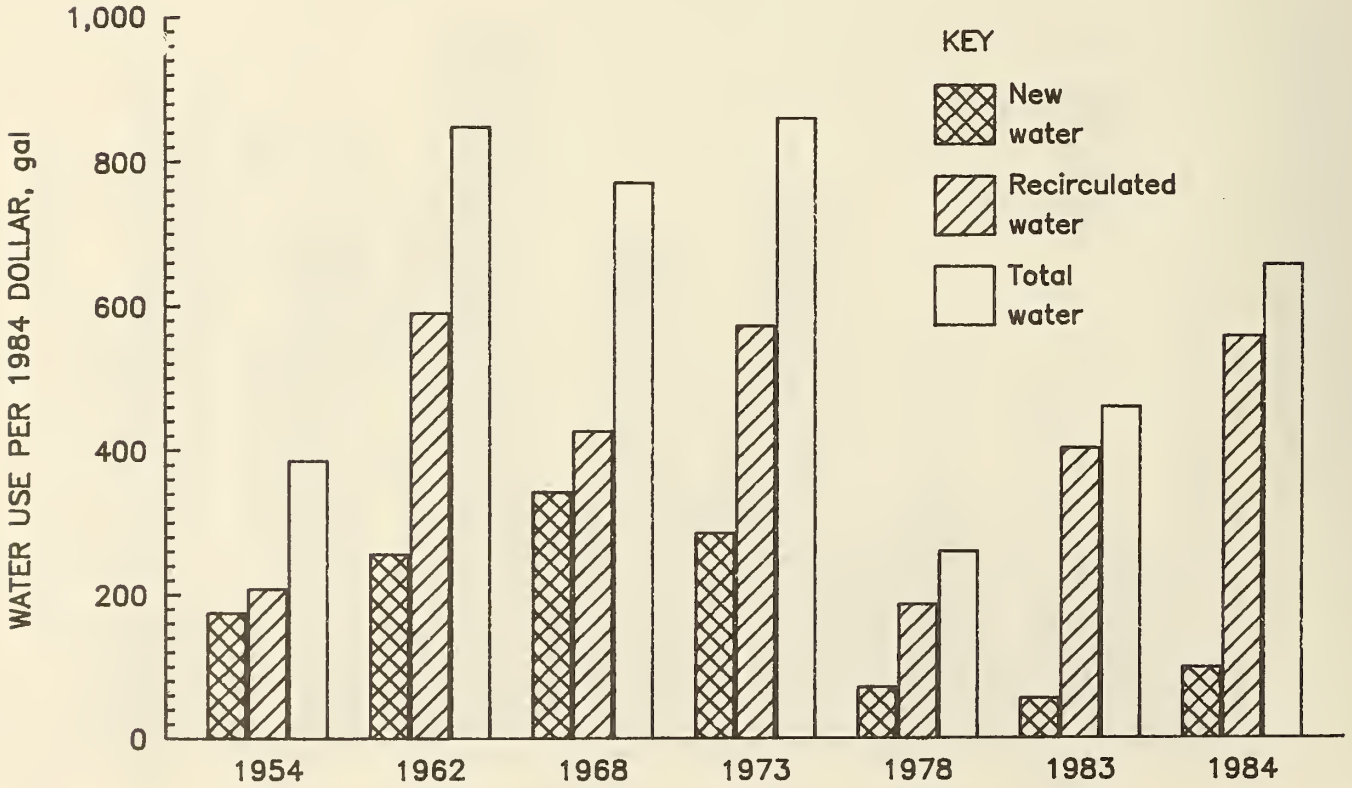

Figure 27.—Phosphate rock industry water use per 1984 dollar of mine production, 1954-84.

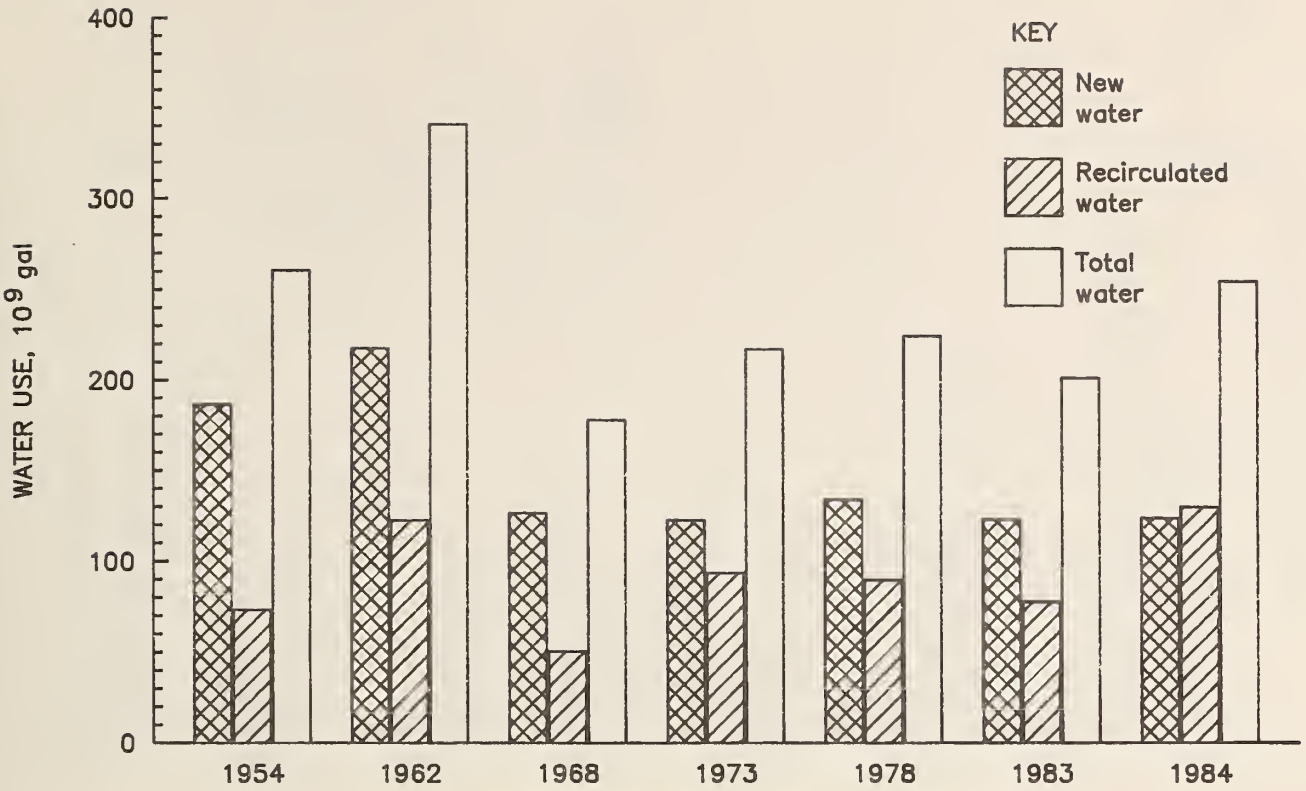

Figure 28.—Sand and gravel industry water use, 1954-84.

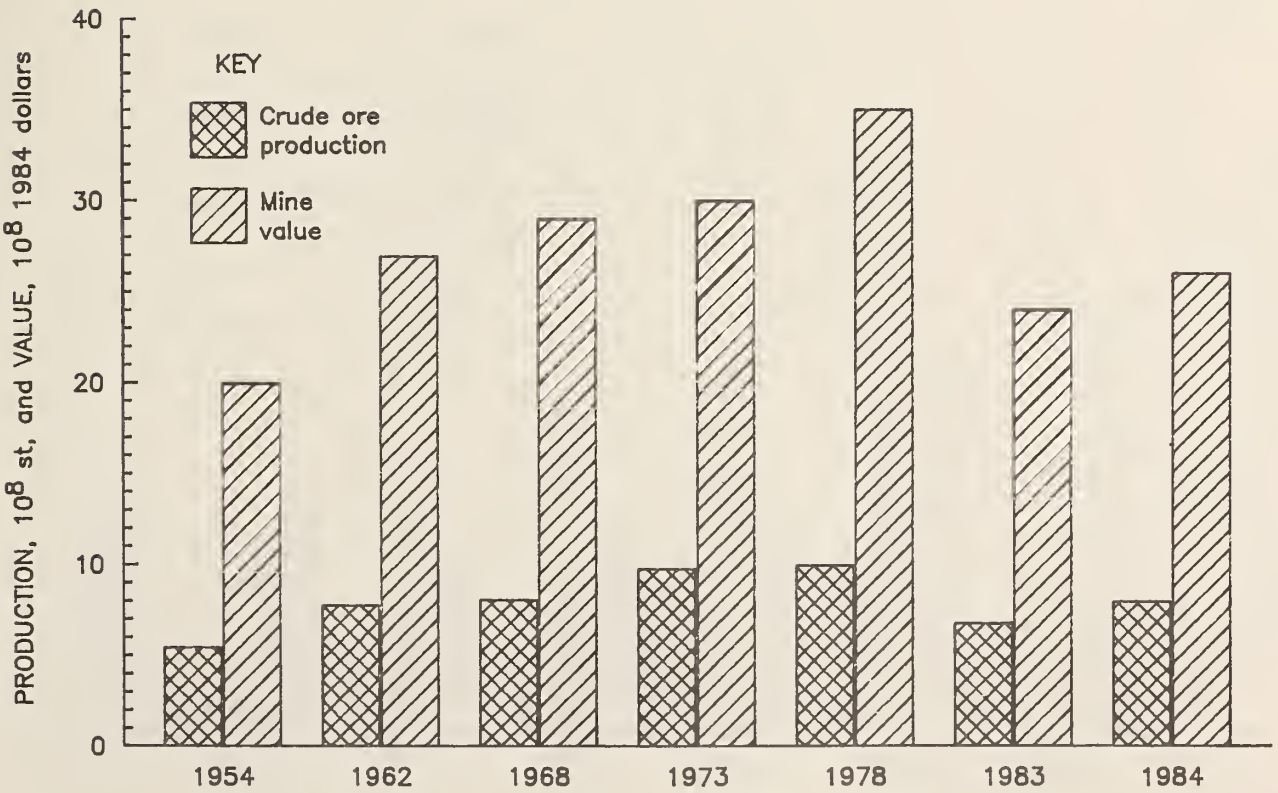

Figure 29.—Sand and gravel industry crude ore production and mine value, 1954-84.

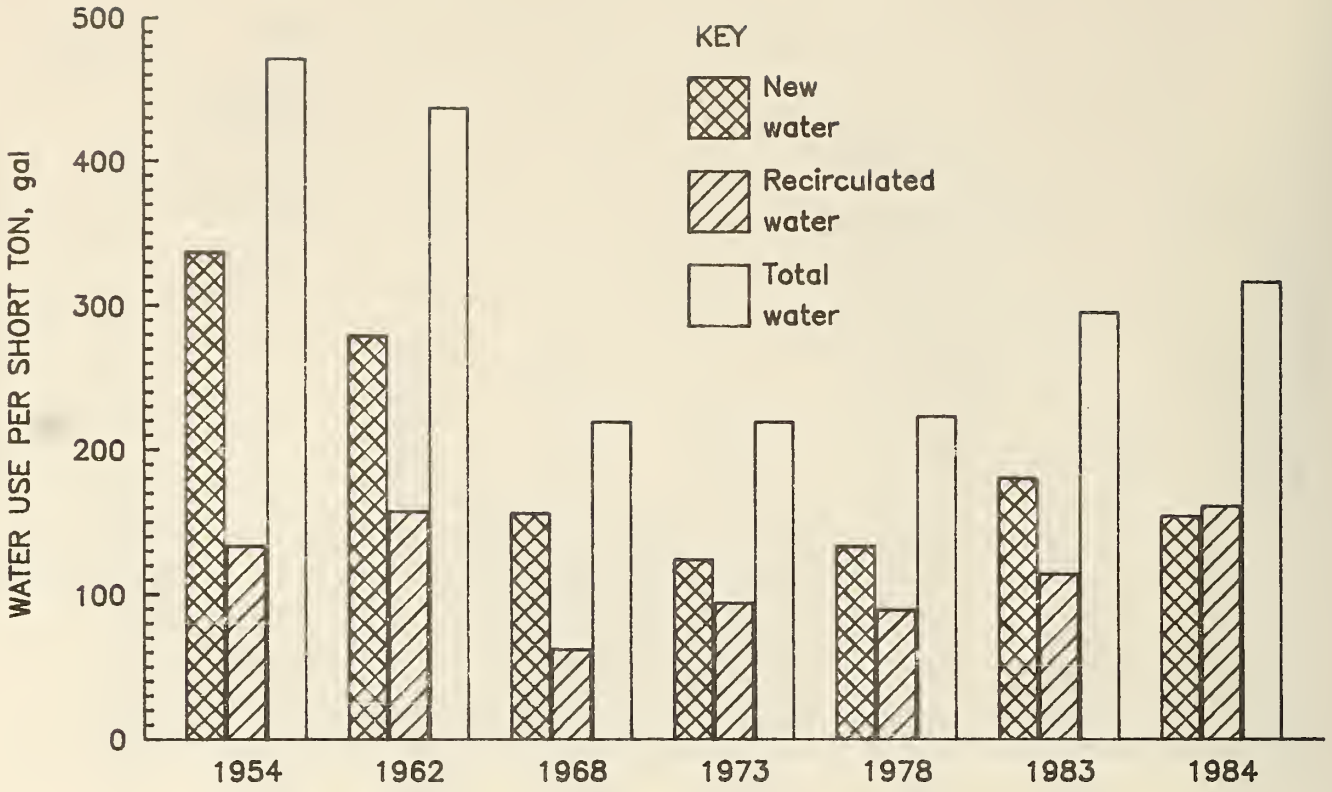

Figure 30.—Sand and gravel industry water use per short ton of crude ore production, 1954-84.

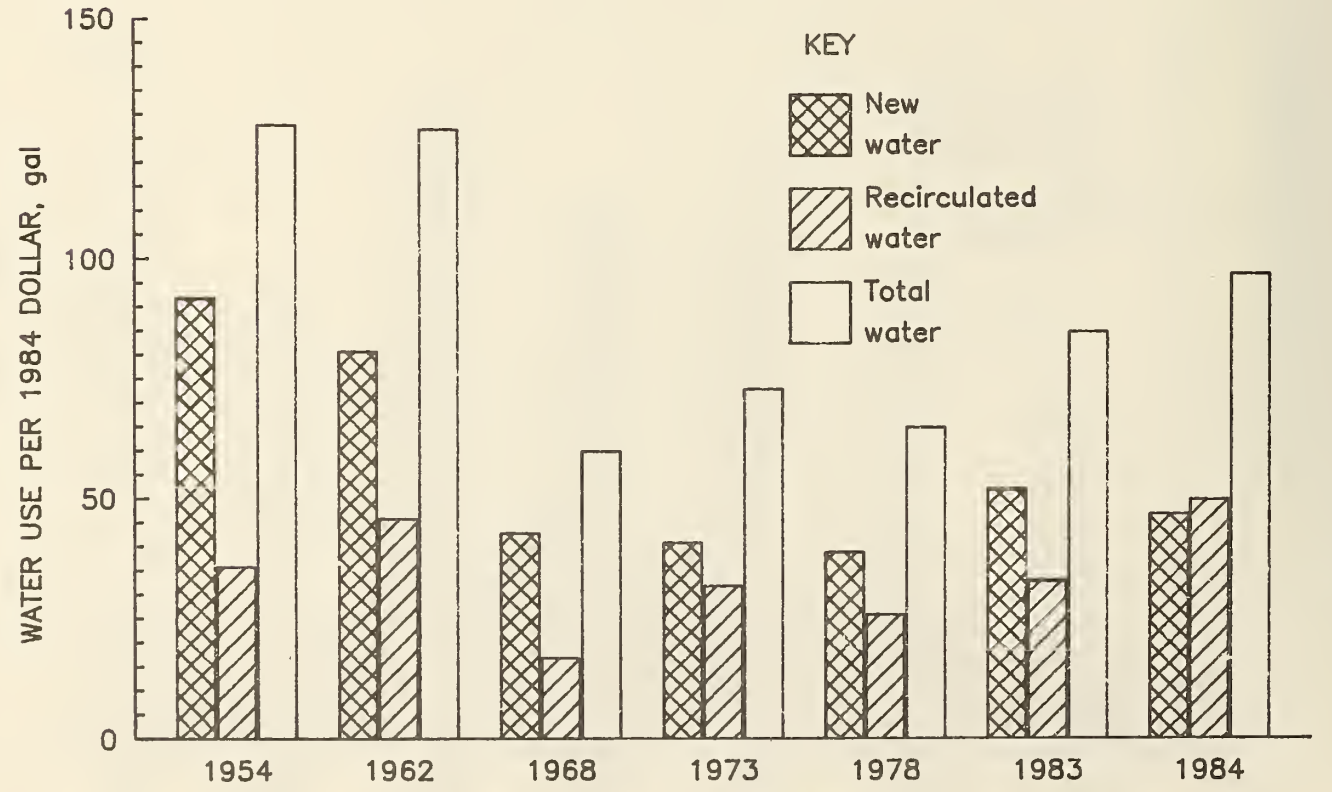

Figure 31.—Sand and gravel industry water use per 1984 dollar of mine production, 1954-84.

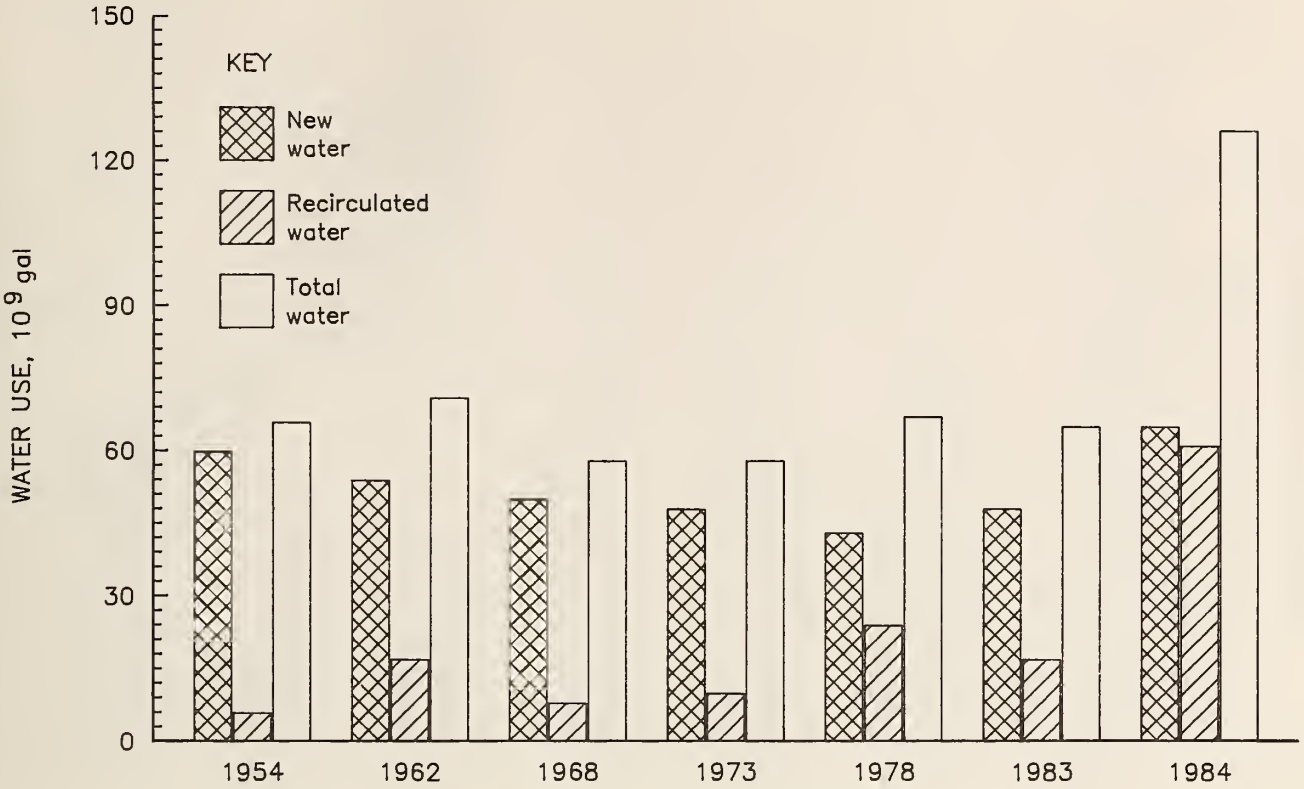

Figure 32.—Stone industry water use, 1954-84.

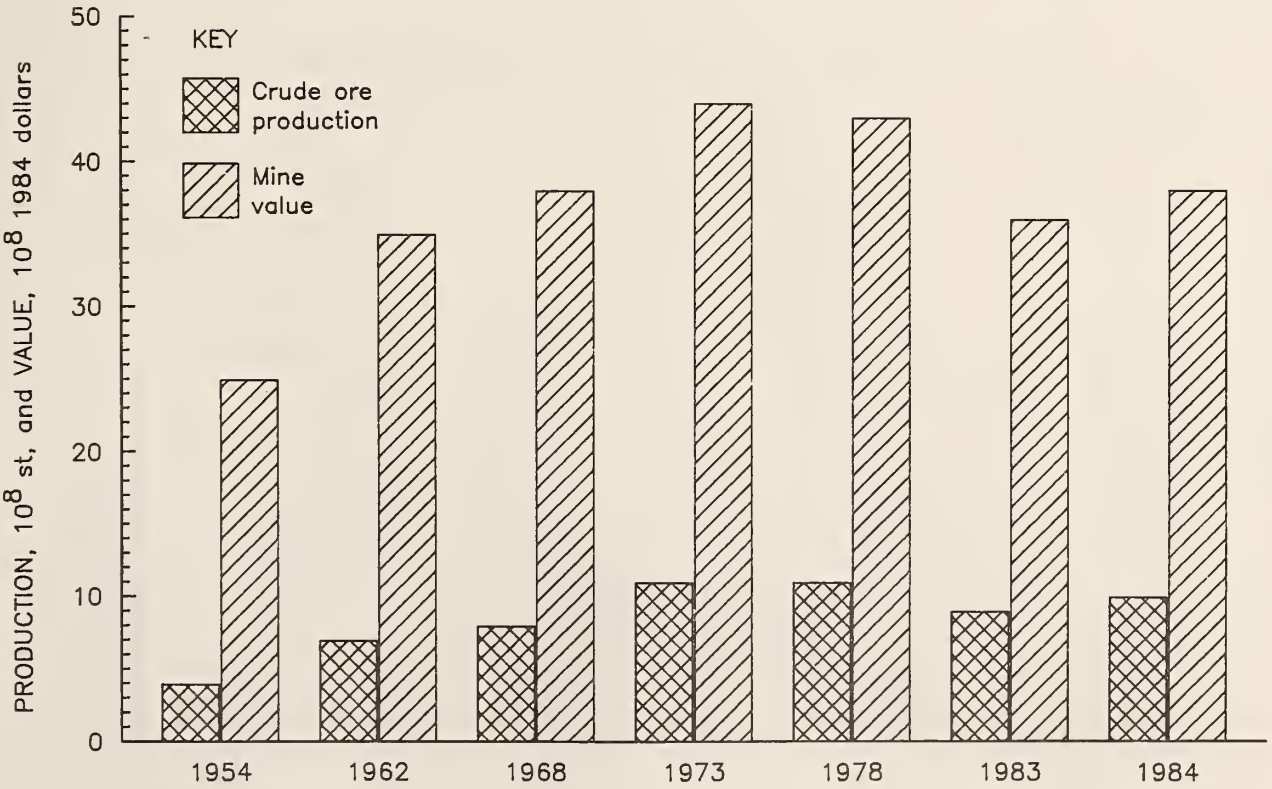

Figure 33.—Stone industry crude ore production and mine value, 1954-84.

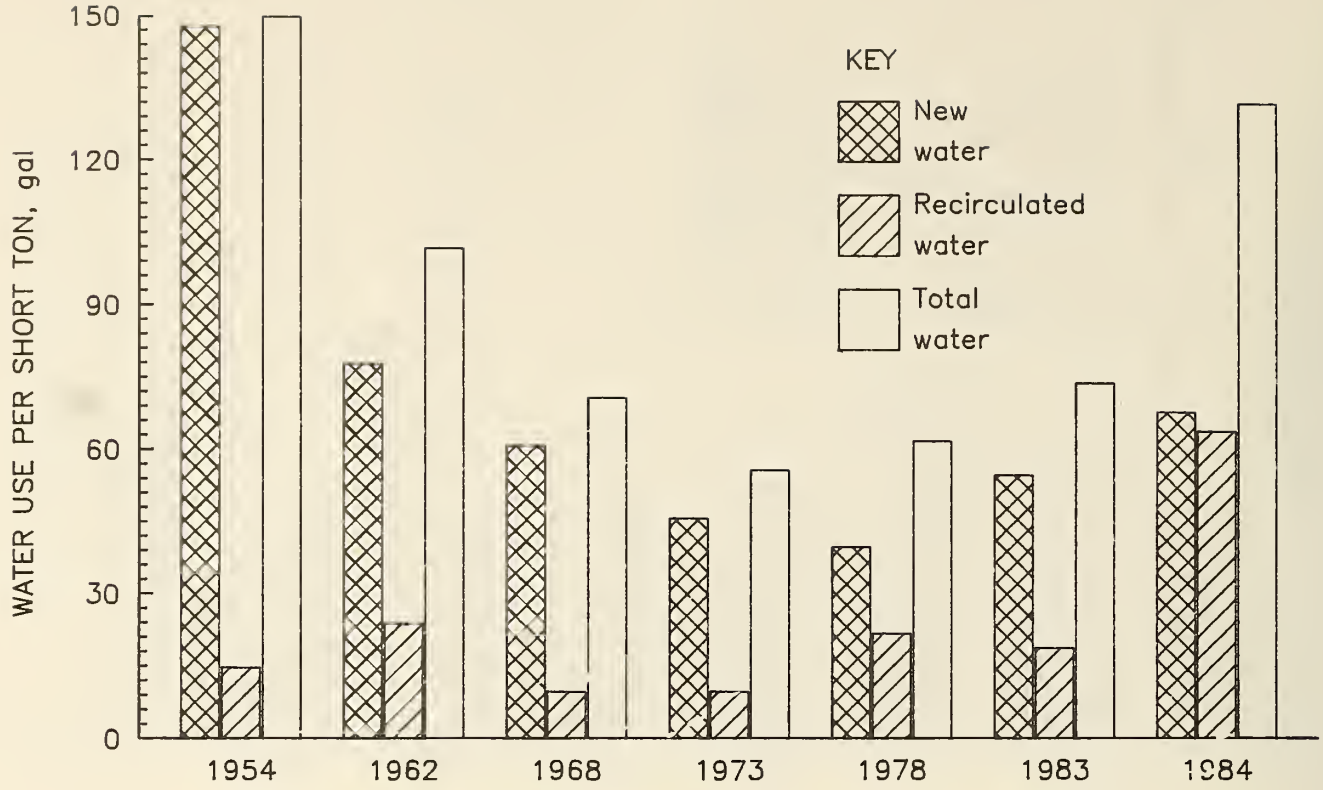

Figure 34.—Stone industry water use per short ton of crude ore production, 1954-84.

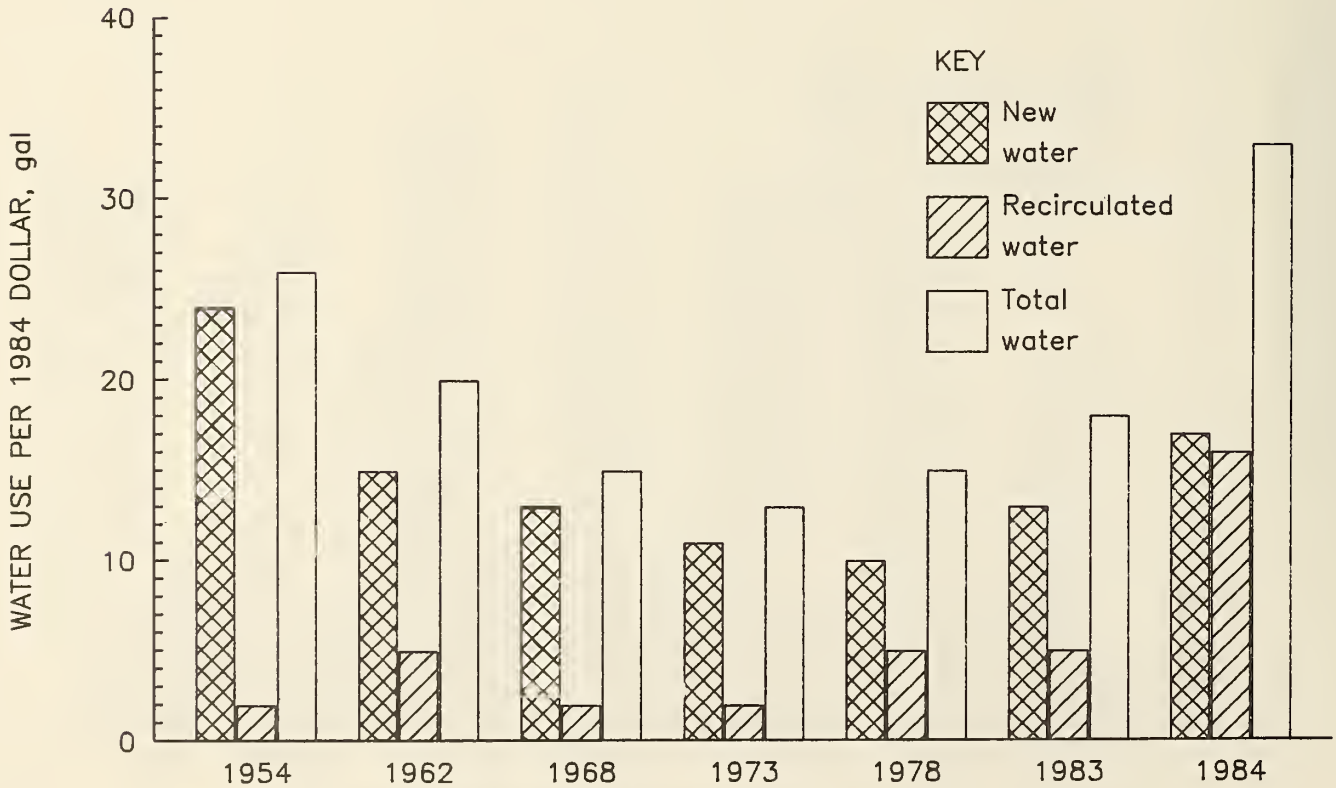

Figure 35.—Stone industry water use per 1984 dollar of mine production, 1954-84.

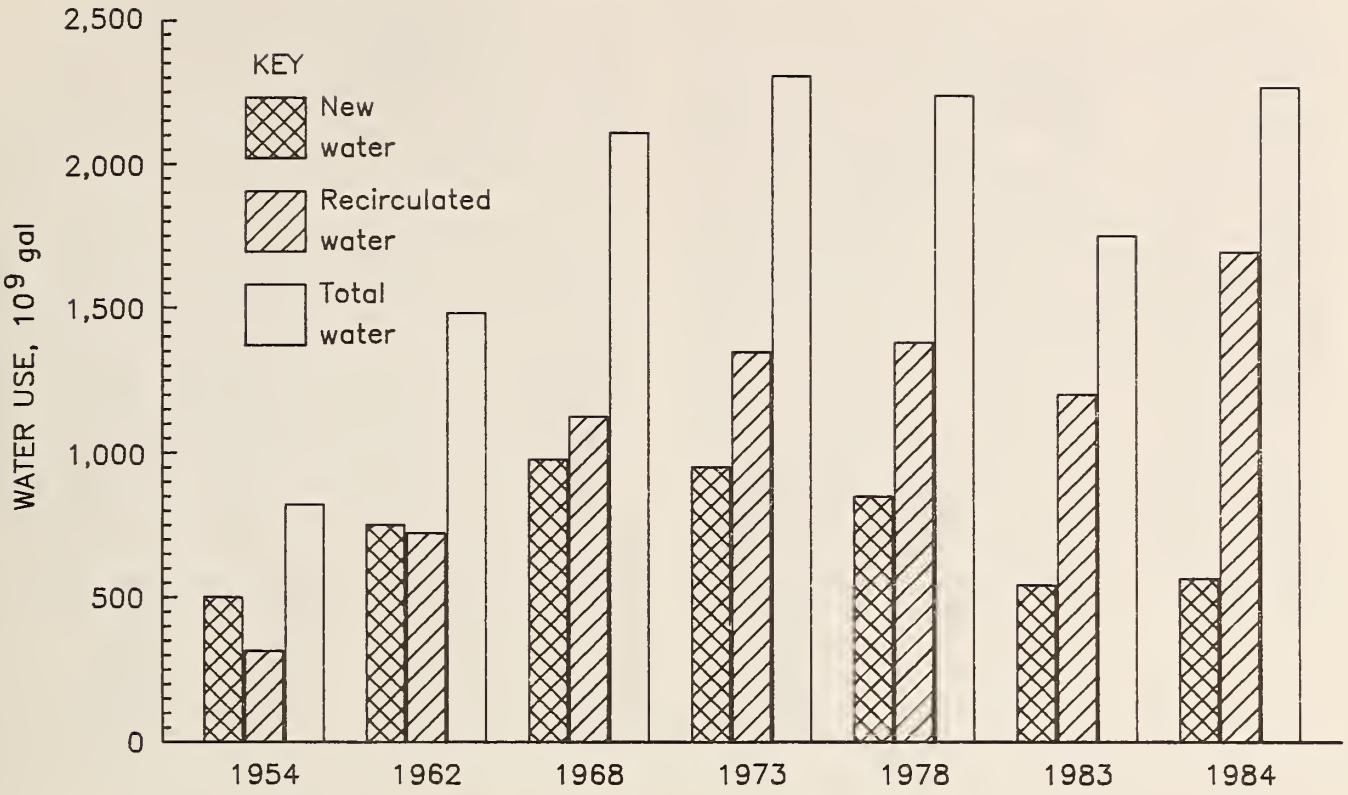

Figure 36.—Nonfuel minerals industry water use, 1954-84.

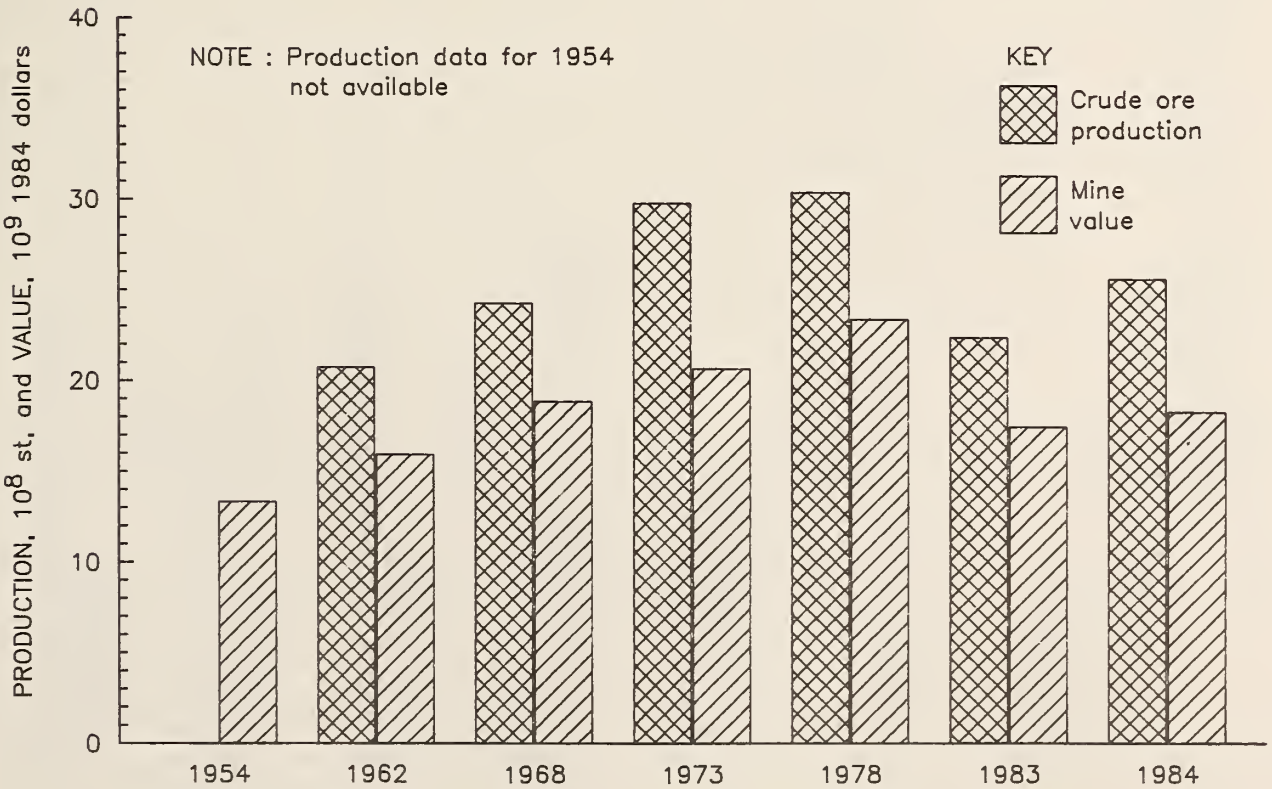

Figure 37.—Nonfuel minerals industry crude ore production and mine value, 1954-84.

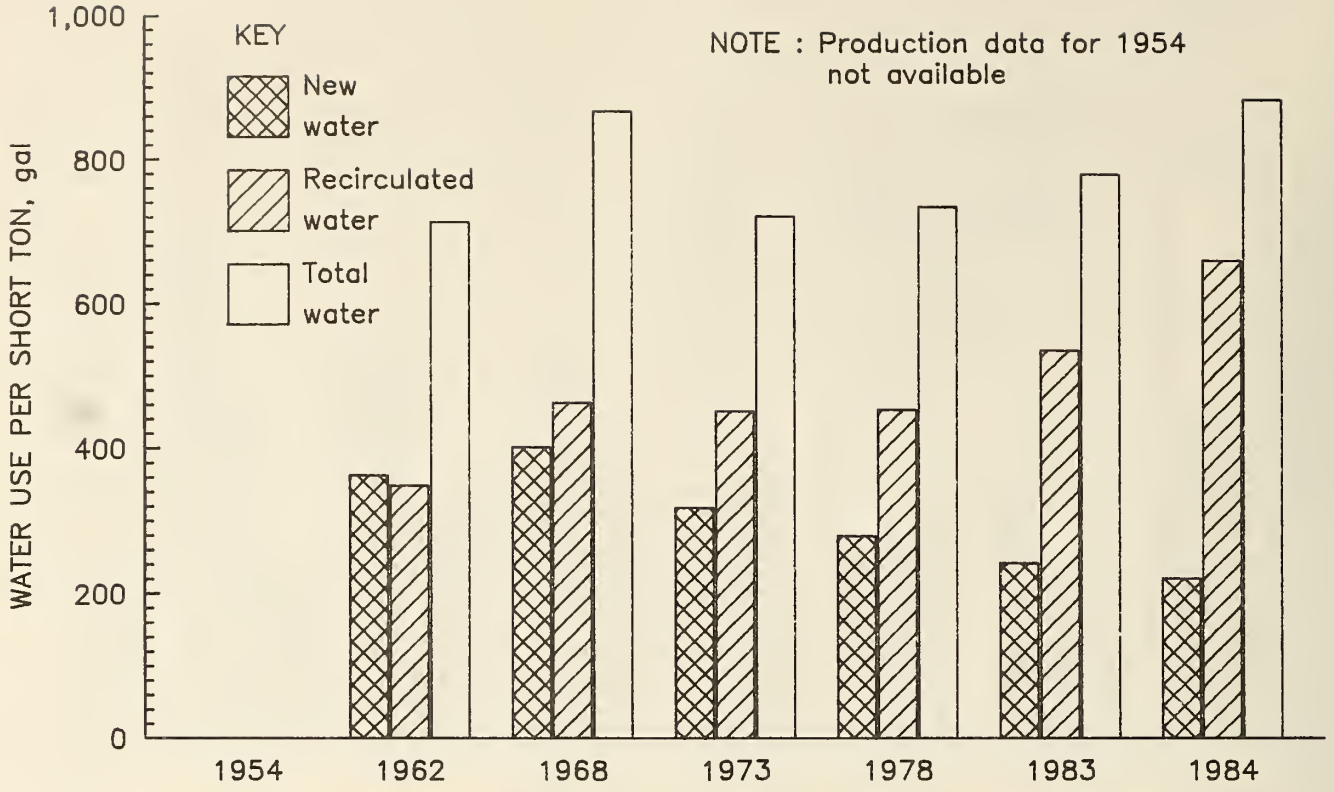

Figure 38.—Nonfuel minerals industry water use per short ton of crude ore production, 1954-84.

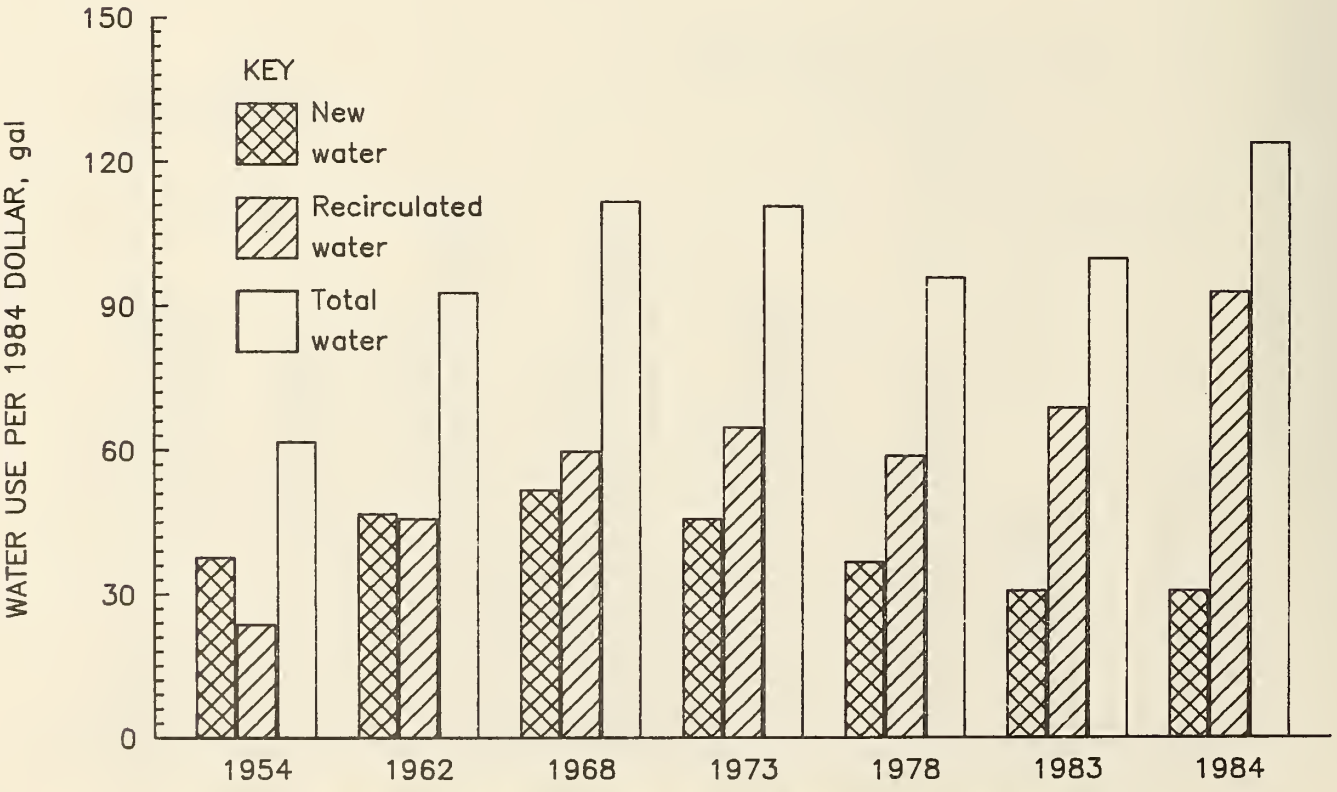

Figure 39.—Nonfuel minerals industry water use per 1984 dollar of mine production, 1954-84.

WATER USE TRENDS, BY STATE

Trends in water usage by individual States could not be meaningfully analyzed because data from the Bureau of the Census were not disaggregated among fuel and nonfuel minerals at the State level. However, a comparison can be made between Bureau of Mines data for 1962 and 1984.

During 1962, the nonfuel minerals industry used 1,487 billion gal of water, of which 758 billion gal was new water and 729 billion gal recirculated water. Ten States accounted for about 70% of total water used (*29*). These were, in decreasing order, Florida, Minnesota, Tennessee, Michigan, California, Arizona, Texas, New Mexico, Ohio, and Utah (fig. 40). In comparison, 571 billion gal of new water and 1,696 billion gal of recirculated water were used by the industry during 1984. Ten States accounted for 85% of total water used. In decreasing order, they were Florida, Minnesota, Michigan, North Carolina, Arizona, California, Texas, Utah, New Mexico, and Illinois (fig. 12).

The decline in new water use and the increase in water recirculation reflected their relative importance to the nonfuel minerals industry during the two time periods. Notably, most of the increase in total water usage was accounted for by Arizona, Florida, Michigan, Minnesota, and North Carolina. These increases were the result of an increase in the production of copper in Arizona, phosphate rock in Florida and North Carolina, and taconites in Michigan and Minnesota.

For a good number of individual States, however, there were sharp relative declines in water use. To some extent, some of these declines could be ascribed to decreases in the production of crushed stone and sand and gravel in these States. In other States, the underlying causes of the declines were varied and included decreases in the production of gold in Alaska, bauxite in Arkansas, molybdenum and uranium in Colorado, lead and zinc in Idaho, copper in Montana, and iron ore in Pennsylvania. The single largest decline in water usage in Tennessee could not be readily explained at this time.

For the most part, there were substantial decreases in the amount of water discharged in a majority of States, possibly in compliance with State and local environmental regulations. On the other hand, the amount of water consumed more than doubled, largely through product incorporation and evaporation.

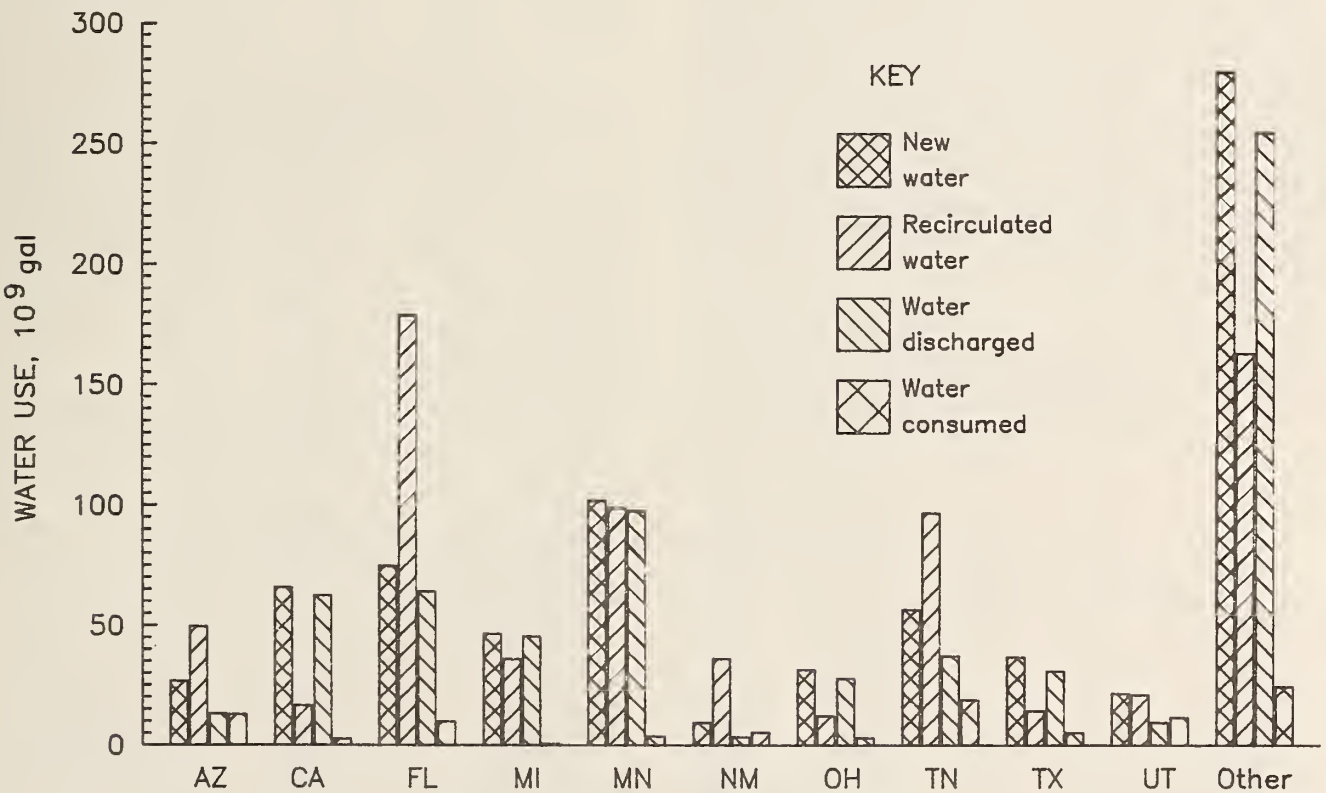

Figure 40.—Water use, by State, 1962 (*29*).

WATER USE IN THE NONFUEL MINERALS INDUSTRY IN 2000

Because of data inadequacy, estimates of future water use could be made only for a selected number of metallic and nonmetallic minerals. Even so, the estimates were derived from a simple nonstatistical methodology described herein.

First, an average intensity-of-use index was calculated for each commodity. This index was obtained by dividing the sum of water use (new, recirculated, or total) by the sum of crude ore production over the period 1983-84. Results of these computations are shown in table 5.

Next, crude ore production in the year 2000 was estimated based on the projections of marketable mine production given in table 6 (*30*). It was assumed that the rate of growth in crude ore production would parallel that in marketable production from 1983 to 2000. Crude ore estimates for 2000 would be as shown in table 7.

Applying the average intensity-of-use indices to projected crude ore production then gave estimates of water use in the nonfuel minerals industry in 2000 (table 8). Total water use in the nonfuel minerals industry was estimated at 2,679 billion gal in 2000, of which 30% would be new water and 70% recirculated water. About 82% of all water would be used in producing copper, crushed stone, iron ore, phosphate rock, and sand and gravel. Compared with 1984 water usage, there would be a slight increase in new water use relative to recirculated water. This would be due primarily to the increase in the production of sand and gravel and of crushed stone, both of which use proportionately more new water than recirculated water for each ton of output. Largely because of its projected high rate of growth in production, the iron ore industry would surpass the phosphate rock industry in total water use in the year 2000.

Table 5.—Average water use per short ton of crude ore production, 1983-84, gallons

Commodity	New water	Recirculated water	Total
Metals:			
Copper	400	652	1,092
Gold and silver	183	190	373
Iron ore	373	3,159	3,532
Lead and zinc[1]	430	167	597
Uranium-vanadium	1,346	492	1,838
Other metals	359	1,304	1,663
Average	387	1,469	1,856
Nonmetals:			
Clays	493	196	689
Phosphate rock	551	3,375	3,926
Potash, soda, borates	953	3,009	3,962
Rock salt[1]	238	258	496
Sand and gravel	167	140	307
Stone	62	42	104
Sulfur[1]	1,854	1,268	3,122
Other nonmetals	1,311	404	1,715
Average	197	403	600
Average, all nonfuel minerals	232	604	836

[1]1984 only.

Table 6.—Mine production in 1983 and 2000

Commodity	Production		Change, %
	1983	2000[e]	
Metals:			
Copper, 10^3 mt	1,038	1,400	35
Gold, 10^3 tr oz	1,957	4,500	130
Iron, 10^6 st Fe content	27	50	85
Lead, 10^3 mt Pb content	449	620	38
Silver, 10^6 tr oz	43	50	16
Uranium-vanadium, st V content	2,433	9,200	278
Zinc, 10^3 mt	275	700	155
Nonmetals:			
Clays, 10^3 st	40,983	70,000	71
Phosphate rock, 10^3 mt	42,573	46,400	9
Potash, 10^3 mt K_2O equivalent	1,429	1,300	-9
Salt, 10^3 st	32,973	51,500	56
Sand and gravel, 10^6 st:			
Construction	655	1,000	53
Industrial	26	50	92
Sodium carbonate, 10^3 st	8,467	12,000	42
Stone:			
Crushed, 10^6 st	863	1,300	51
Dimension, 10^3 st	1,186	770	-35
Sulfur, 10^3 mt	9,290	15,700	69

[e]Estimated.

Table 7.—Crude ore production in 1983 and 2000

Commodity	Production, 10^6 st		Change, %
	1983	2000[1]	
Metals:			
Copper	196.0	264.6	35
Gold	40.4	92.9	130
Iron ore	128.0	236.8	85
Lead	8.4	11.6	38
Silver	9.5	11.0	16
Uranium-vanadium	10.2	38.6	278
Zinc	5.7	14.5	155
Other metals	28.9	[2]48.6	68
Total	427.0	718.6	68
Nonmetals:			
Clays	40.6	69.4	71
Phosphate rock	141.0	153.7	9
Potash	13.8	12.6	-9
Rock salt	10.1	15.8	56
Sand and gravel:			
Construction	[3]655.1	1,002.3	53
Industrial	[3]26.6	51.1	92
Sodium carbonate, natural	6.7	9.5	42
Stone:			
Crushed	868.0	1,310.7	51
Dimension	2.6	1.7	-35
Sulfur, Frasch	[3]4.5	7.6	69
Other nonmetals	47.2	[2]70.3	49
Total	1,816.2	2,704.7	49
Grand total or average	2,243.2	3,423.3	53

[1]Estimates based on data in table 6.
[2]Estimates based on aggregate change in foregoing commodities.
[3]Marketable production.

NOTE:—Data may not add to totals shown owing to independent rounding.

Several assumptions were implicit in the foregoing estimates of future water use:

Water use was determined solely by the level of crude ore production.

No technological changes were to occur between 1983 and 2000 to drastically alter water use patterns in the nonfuel minerals industry.

Ore grades would remain unchanged through the end of the century.

No major changes in State and local environmental regulations would occur that would have a significant impact on water use.

Table 8.—Estimated water use in the nonfuel minerals industry in 2000, billion gallons

Commodity	New water	Recirculated water	Total
Metals:			
Copper	116	173	289
Gold and silver	19	19	38
Iron ore	88	748	836
Lead and zinc	11	4	15
Uranium-vanadium	52	19	71
Other metals	17	63	80
Total	303	1,026	1,329
Nonmetals:			
Clays	34	14	48
Phosphate rock	85	519	604
Potash, soda, borates	21	66	87
Rock salt	4	4	8
Sand and gravel	176	147	323
Stone	81	55	136
Sulfur	14	10	24
Other nonmetals	92	28	120
Total	507	843	1,350
Grand total	810	1,869	2,679

An average intensity-of-use index for each commodity over the period 1983-84 would apply for the remainder of the century.

At the present time, it cannot be determined if the estimates for individual commodities are realistic, because there are no comparative estimates from other sources. In the past, projections of future water use had been made by several public and private-sector organization, including the Senate Select Committee on National Water Resources (*22*), Resources for the Future (*23*), the National Water Commission (*24*), the U.S. Water Resources Council (*25*, pp. 95-101) and the Senate Committee on Environment and Public Works (*26*). Most of the projections were for new water withdrawals and consumption, based on anticipated growth in population, economic activity, and technology. However, no attempt had been made to estimate water use by individual commodities. Depending on the methodology employed, projections of future water use could differ considerably from one another. Thus, the Water Resources Council estimated freshwater withdrawal by metal mines at 1.36 billion gal/d (496 billion gal/yr) and by nonmetal mines at 6.12 billion gal/d (2,234 billion gal/yr) in 2000. The total annual freshwater withdrawal of 2,730 billion gal is more than three times the Bureau's new water estimate shown in table 8. While earlier Bureau of Mines studies on water use in Montana (*20*), Nevada (*19*), New Mexico (*18*), and Wyoming (*21*) contained estimates of water requirements in the mineral industries in those States in the year 2000, these estimates could not be compared with those in table 8 because they pertained to a selected number of individual States only. Also, these estimates included water usage in smelting and refining of ores.

The work of Kaufman and Nadler (*12*) illustrates the need for continual revisions in water use projections as new data become available. With 1962 as a base year, they developed mathematical expressions for estimating water use in the minerals industry to the year 1985 (table 9). A comparison of these estimates with average water use data for 1983-84 indicates the difficulty of correctly projecting water use more than 20 yr into the future.

Table 9.—Average 1983-84 water use and estimated 1985 water use (*12*), billion gallons

Commodity	Average 1983-84 water use			Estimated 1985 water use		
	New water	Recirculated water	Total	New water	Recirculated water	Total
Copper	86	127	213	176	168	344
Iron ore	57	480	537	221	229	450
Phosphate rock	89	545	634	343	679	1,022
Sand and gravel	124	104	228	957	437	1,394
Other	204	194	398	388	611	999
Total	560	1,450	2,010	2,085	2,124	4,209

WATER USE PROBLEMS AND ISSUES

Current and potential problems associated with water use in the nonfuel minerals industry were not addressed in the water canvass, but based on published data, they appear to be generally related to water availability, water quality, and land use. Because copper, crushed stone, iron ore, phosphate rock, and sand and gravel are major users of water, the following discussion will focus largely on them.

WATER AVAILABILITY

Although a vast majority of respondents in the water canvass indicated their new water supplies to be adequate for 5 to 20 yr under conditions then existing, it could not be determined whether such supplies would be available in the future under a different set of political, economic, and demographic conditions. A case in point is Arizona, and Michigan provides another perspective.

Arizona, which produces about 70% of the Nation's copper, has an arid climate and limited surface water resources. About 60% of the new water withdrawal in the State is derived from ground water resources, which are being depleted 1.7 times faster than they can be replenished (*26*). Overdraft of ground water is thus a serious problem throughout the State. In the Tucson area, near where the major copper producers are located, the ground water is subject to such competing uses as agriculture, mining, and public supply. Already, there are indications of strain among some users. In 1984, Anamax Mining Co., which operated a small solvent extraction-electrowinning plant at the Twin Buttes Mine, was sued by the U.S. Government, the Papago Indian Tribe, and others for allegedly withdrawing excessive amounts of surface and ground water from the Santa Cruz River Basin in derogation of plaintiffs' rights to it. The action resulted in the closure of the operation in 1985, with a loss of 156 jobs.

It seems likely that ground water withdrawals will continue to increase in support of a growing population in the Tucson area. It seems likely also that ground water levels will continue to decline because withdrawal rates are expected to exceed recharge rates. As future water levels decline, pumping costs will increase, well capacities will be reduced, water quality will tend to deteriorate, and there is a potential for water rights to become an issue of major proportions. All this may have an adverse impact on future copper production in Arizona.

The future of iron ore operations of Cleveland Cliffs, Inc. (CCI), at the Tilden Mine in Michigan seems likely to depend on the availability of an alternative water supply for the neighboring city of Ishpeming. In April 1987, CCI announced plans to relocate the mine north of the existing ore body in order to profitably exploit a higher grade magnetite deposit. The relocation would entail the draining of Schoolhouse and Foster Lakes (which overlie the deposit) and damming of the southeast end of Lake Ogden. Tilden Lake would be used for dumping stripped overburden. All of these lakes form the Lake Sally watershed, from which the city obtains its water supply. It is estimated that up to 50% of the watershed would be depleted by the planned relocation of the mine. City council members have suggested that they would oppose the relocation if CCI were unable to provide the city with financial assistance for the construction of a new water supply system. Iron ore production in Michigan, which accounts for about one-fourth of U.S. production, would be severely impacted should CCI be prevented from proceeding as planned.

WATER QUALITY

Enormous amounts of waste are generated annually in the processing of minerals, and they have to be disposed of in accordance with Federal, State, and local environmental regulations. These wastes are usually in the form of solid particles carried in discharge water from the processing plants.

In the longest and most historic environmental conflict, the U.S. Department of Justice tried Reserve Mining Co. on August 1, 1973, for allegedly polluting Lake Superior with taconite tailings discharged from the company's plant at Silver Bay, MN. The trial lasted several years and resulted in Reserve Mining's agreement to construct a land disposal site about 4 miles from the Silver Bay plant. Completed in 1980, the disposal site, designated as "Milepost 7," required about 200 permits from State agencies and cost several hundred million dollars. The permits were granted subject to 12 stringent conditions designed to protect the environment and to mitigate the potential health threat from asbestiform fibers in the taconite. Covering an area of 5.8 mi^2, the disposal site was designed to contain some 700 million st of tailings over a 40-yr period. When Reserve Mining went into Chapter 11 bankruptcy in 1986, the Minnesota Department of Natural Resources estimated that it would cost up to $57 million to permanently close the site.

In addition to containing solid material, most process water contains various amounts of chemical reagents that are used in the selective flotation of minerals. These reagents are potential pollutants and have to be removed from wastewater prior to discharge. The cost of pollution abatement can be considerable. In 1983, annual operating costs for pollution control amounted to $34.2 million in iron ore production, $27.3 million in phosphate rock, and $5.2 million in copper ore (*11*). Because no chemical reagents were used in processing crushed stone and sand and gravel, total operating costs for pollution abatement in these industries amounted to only $6.4 million. Pollution control costs can generally be expected to increase with any foreseeable increase in mineral production. Costs will also increase with tighter effluent standards unless more efficient pollution control technologies can be developed and installed at existing facilities.

LAND USE

Large amounts of land are utilized in the nonfuel minerals industry for the dual purpose of solid waste disposal and water reclamation. After settlement of particulate matter, water flowing out of the disposal site is recycled back to the processing plant for further use. In 1983, some 32,000 acres of land were used for disposal of wastes from iron ore mines, 41,000 acres for wastes from phosphate rock mines, and 15,000 acres for wastes from copper mines (*11*). Crushed stone and sand and gravel together used about 10,000 acres.

Because crushed stone and sand and gravel operations are located near urban areas where most new residential and commercial construction takes place, the amount of land available for waste disposal can be severely limited by local zoning laws. The issue becomes a dichotomy between the need for urban construction and the production of construction materials that supports it. Doubtless, this issue will prevail far into the future unless alternative materials can be developed for building construction.

Although most new waste disposal sites are designed and constructed according to rigid environmental standards, some potential problems may yet be encountered. These include embankment failure and erosion by wind and rain, causing the release of large quantities of sediment into the environment. Where the waste contains sulfide ores, water percolating through it may result in acid drainage into surrounding areas. Constructing and maintaining a leakproof waste disposal site containing sulfide material can be a costly undertaking.

Another large cost associated with waste disposal is land reclamation in accordance with bonded procedures agreed upon during the permitting process. Most States require mined land, including waste disposal sites, to be restored to its former or next higher use before a bond posted by the operator can be released. Largely because of this, many acres of previously mined land have been successfully reclaimed in recent years. But much work still remains to be done to expedite land reclamation in Florida. Phosphate slimes are estimated to cover more than 100,000 acres of land in Florida. Because of the nature of the slimes, particle settlement is slow, and successful reclamation usually takes several years. Thus, the operator's reclamation bond is tied up for a long period of time before it can be used for a new venture. In order to assist the phosphate industry in its reclamation efforts, the Bureau of Mines has been developing techniques for the large-scale dewatering of phosphate slimes (*31*). Industry itself appears to have made some progress in this endeavor. A dewatering process has been reported that will reclaim land for agricultural and livestock use in about 4 yr at a cost of $2,000 per acre (*32*).

Another problem facing the phosphate rock industry in Florida is the preservation of wetlands. The State contains over 20% of the remaining wetlands in the United States, and these areas are being rapidly depleted by coastal development, agricultural drainage, and urban expansion. The preservation of remaining wetlands has become a primary concern among certain public and governmental groups, and has led regulatory agencies to restrict mining of swamps and marshes unless mitigative measures can be demonstratively employed, such as at Agrico's Fort Green Mine in Polk County. Thus, development of techniques for restoring wetlands may well be a top priority for the Florida phosphate rock industry in the future.

Watershed preservation is also an issue in the phosphate rock industry in Florida. After nearly 10 yr of attempts to obtain permits to develop the Duette deposit in Manatee County, Estech Inc. subsequently sold the 10,500-acre site to the county in 1985. Environmental concerns over the Lake Manatee watershed, which supplies Manatee and Sarasota Counties with drinking water, had delayed the development of the project. Manatee County purchased the property for a reported $26 million in order to protect the watershed.

It can thus be seen that land use restraints and conflicts are typically the types of problems that are likely to be encountered in the disposal of water-bearing wastes. How well these problems can be satisfactorily resolved will determine the level of future production in the nonfuel minerals industry.

SUMMARY

Total water use in the domestic nonfuel minerals industry amounted to an estimated 2,267 billion gal in 1984, of which 75% was recirculated water and 25% new water. Among all metallic and nonmetallic mineral industries, the single largest user was the phosphate rock industry, which accounted for more than one-third of all water used. The next largest users were copper, crushed stone, iron ore, and sand and gravel industries, together accounting for 55% of the total.

Among all States, Florida was by far the largest user, accounting for about one-third of all water used, most of it in its phosphate rock industry. The iron ore industry of Michigan and Minnesota used 30% of all water, while the copper industry of Arizona, New Mexico, and Utah used 10%. Large amounts of water were also used in North Carolina (6% of total), California (3%), Texas (2%), and Illinois (2%).

Between 1954 and 1984, new water use appeared to be declining and water recirculation increasing in their relative importance to the nonfuel minerals industry. For the most part, the increase in water recirculation could be ascribed to the processing of larger tonnages of low-grade ores, but some of the increase could also have been the result of economic and environmental considerations affecting new water use and discharge.

Total water use in the nonfuel minerals industry was estimated to be 2,679 billion gal in the year 2000, of which 30% would be new water and 70% recirculated water. More than 80% of the water would be used in producing copper, crushed stone, iron ore, phosphate rock, and sand and gravel.

Current problems and issues associated with water use in the nonfuel minerals industry include water availability, water quality, and land use. Although technology and institutional and regulatory procedures are already in place to solve some of these problems and issues, new approaches may be needed to solve others in order that production of copper, crushed stone, iron ore, phosphate rock, and sand and gravel can continue into the future.

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APPENDIX A.—CANVASS QUESTIONNAIRE

Form 6-P118
(7-85)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
WASHINGTON, D.C. 20241

WATER USED IN THE
NON-FUEL MINERAL INDUSTRY
1984

Form Approved
O.M.B. No. 1032-0117

INDIVIDUAL COMPANY
DATA-PROPRIETARY

Unless authorization is granted in the section above the signature, the data furnished in this report will be treated in confidence by the Department of the Interior, except that they may be disclosed to Federal defense agencies, or to the Congress upon official request for appropriate purposes.

Collection of non-fuel minerals information is authorized by Public Law 62-386 and the Defense Production Act. This information is used to support executive policy decisions pertaining to emergency preparedness and defense and analyses for minerals legislation and industrial trends. The Bureau relies on your voluntary and timely response to assure that its information is complete and accurate.

(Please correct if name or address has changed.)

Please complete this form and return one copy to the Bureau of Mines in the enclosed envelope. Complete a separate form for each operating unit using reasonable estimates when exact data are not available.

1. IDENTIFICATION AND LOCATION OF OPERATING UNIT.

A. Name of operation_____

B. Commodity_____

C. Location: County_____ State_____

D. If the operation was inactive the entire year of 1984, check here ☐ sign, and return this form.

2. MINING AND PROCESSING ACTIVITIES COVERED BY THIS REPORT (check all pertinent boxes).

A. Mining Activities:

☐ Underground ☐ Placer ☐ Well or pumping operation
☐ Open pit or strip ☐ Dredging ☐ Other (specify)_____
☐ Quarrying ☐ In-place leaching _____

B. Processing Activities:

☐ Washing ☐ Chemical extraction ☐ Smelting
☐ Crushing & grinding ☐ Roasting ☐ Other (specify)_____
☐ Screening ☐ Sintering _____
☐ Concentration ☐ Retorting

3. WATER USAGE DURING 1984.

A. Was water used in the performance of activities checked in Section 2? ☐ (1) Yes ☐ (2) No

B. If not, sign and return form.

C. If new water intake exceeded 1,000,000 gallons per year complete Section 4 through 9.

(OVER)

4. NEW WATER BY SOURCE. Report quantity of new (intake or make-up) water brought into the mine or plant for the first time.

Source (1)	Code	Gallons per year (2)
Stream or river	401	
Lake or reservoir	402	
Mine water	403	
Ground water	404	
Other (specify) _____		
TOTAL	499	

5. ADEQUACY OF NEW WATER SUPPLY: Code 501

A. Is your water supply adequate at present? (1) Yes ☐ ; (2) No ☐

B. If yes, for how long do you believe your water supply will be adequate? *(check one)* 5 years ☐ ; 10 years ☐ ; 20 years ☐

C. If supply is not adequate, how much additional water would you require based on your present annual level of operation? _____ gallons per year.

6. RECIRCULATED WATER (report quantity of water that was recirculated or reused in the mine or plant for the purpose of conserving water): _____ gallons per year.
Code 601

7. TOTAL WATER USED. Report total new water Section 4, plus recirculated water Section 6.

Use (1)	Code	Gallons per year (2)
Mining	701	
Processing	702	
Other (specify) _____		
TOTAL	799	

8. WATER DISPOSED.

Disposed (1)	Code	Gallons per year (2)
A. Water discharged from mine or plant	801	
B. Water consumed (evaporation or lost in product; should equal new water (4) minus water discharged (8A)	802	

9. WATER TREATED. Report <u>percentage</u> of each type of water treated (includes settling, filtering, areating, softening, precipitating, pH control, other).

NEW WATER :_____% RECIRCULATED :_____% DISPOSED :_____%

If you desire a copy of the published report, please check this box. ☐

Remarks :

Name of person to be contacted regarding this report			Tel. area code	No.	Ext.
Address	No.	Street	City	State	Zip

May tabulations be published which could indirectly reveal the data reported above? ☐ (1) Yes ☐ (2) No

Signature	Title	Date

APPENDIX B.—CANVASS COVERAGE

Table B-1.—Canvass coverage, by number of operations and commodity, 1984

Commodity	Operations	Respondents	
		Number	%
Metals:			
Antimony	1	1	100
Bauxite	8	6	75
Beryllium	1	1	100
Copper	24	20	83
Gold:			
Lode	52	27	52
Placer	26	17	65
Iron ore	22	19	86
Lead	12	10	83
Manganiferous ore	3	2	67
Mercury	1	1	100
Molybdenum	4	2	50
Platinum	1	1	100
Rare earths	1	1	100
Silver	26	16	62
Tin	1	1	100
Titanium (ilmenite)	2	2	100
Tungsten	3	2	67
Uranium-vanadium	74	55	74
Zinc	12	11	92
Zirconium	1	1	100
Total or average	275	196	71
Nonmetals:			
Aplite	1	1	100
Asbestos	2	2	100
Barite	7	4	57
Bromine	5	2	40
Calcium chloride	3	3	100
Clays	243	181	74
Diatomite	5	5	100
Feldspar	11	10	91
Fluorspar	1	1	100
Garnet	1	1	100
Nonmetals—Continued			
Gypsum	57	47	27
Iodine	2	2	100
Lithium minerals	1	1	100
Magnesite and brucite	1	1	100
Magnesium compounds	8	5	63
Mica, scrap	4	4	100
Olivine	3	1	33
Perlite	3	3	100
Phosphate rock	38	35	92
Potash	10	8	80
Pumice	4	3	75
Pyrophyllite	1	1	100
Salt:			
Evaporated	29	23	79
Rock	14	13	93
Salt in brine	33	25	76
Sand and gravel:			
Construction	27	10	37
Industrial	77	41	53
Soapstone	1	1	100
Sodium carbonate, natural	6	6	100
Sodium sulfate, natural	3	2	67
Stone:			
Crushed	2,261	1,443	64
Dimension	8	5	63
Sulfur, Frasch	7	6	86
Talc	7	5	71
Tripoli	1	1	100
Vermiculite	2	2	100
Volcanic cinder	12	9	75
Wollastonite	1	1	100
Total or average	2,890	1,894	66
Grand total or average	3,165	2,090	66

Table B-2.—Canvass coverage, by number of operations and State, 1984

State	Operations	Respondents	
		Number	%
Alabama	63	44	70
Alaska	28	15	54
Arizona	44	29	66
Arkansas	49	33	67
California	136	99	73
Colorado	64	43	67
Connecticut	14	5	36
Delaware	1	1	100
Florida	118	73	62
Georgia	93	54	58
Guam[1]	2	1	50
Hawaii	19	16	84
Idaho	32	24	75
Illinois	122	90	74
Indiana	81	48	59
Iowa	147	64	44
Kansas	80	50	63
Kentucky	101	71	70
Louisiana	30	19	63
Maine	6	2	33
Maryland	30	23	77
Massachusetts	30	15	50
Michigan	51	33	65
Minnesota	43	34	79
Mississippi	17	14	82
Missouri	169	113	67
Montana	26	14	54
Nebraska	15	8	53
Nevada	55	38	69
New Hampshire	4	0	0
New Jersey	34	20	59
New Mexico	59	39	66
New York	87	66	76
North Carolina	108	51	47
North Dakota	3	2	67
Ohio	125	98	78
Oklahoma	65	43	66
Oregon	50	40	80
Pennsylvania	157	113	72
Puerto Rico[1]	24	16	67
Rhode Island	3	1	33
South Carolina	49	29	59
South Dakota	14	8	57
Tennessee	127	98	77
Texas	216	133	62
Utah	41	30	73
Vermont	12	9	75
Virgin Islands[1]	2	1	50
Virginia	104	66	63
Washington	59	37	63
West Virginia	40	32	80
Wisconsin	78	54	69
Wyoming	38	31	82
Total or average	3,165	2,090	66

[1]U.S.-administered islands and commonwealth.

Table B-3.—Canvass coverage, by crude ore production, 1984, million short tons

Commodity	Ore production		Coverage, %
	Respondents	U.S. total	
Metals:			
Bauxite	0.8	1.1	73
Copper	161.6	193.0	84
Gold:			
Lode	[1]12.2	40.5	30
Placer	7.7	8.5	91
Iron ore	137.8	176.0	78
Lead	5.5	5.6	98
Silver	6.9	7.9	87
Titanium	W	W	100
Uranium-vanadium	2.3	2.8	82
Zinc	5.6	5.8	97
Other metals	[2]34.3	[3]34.9	98
Total or average	374.7	476.1	79
Nonmetals:			
Barite	.1	1.1	9
Calcium chloride	([4])	NA	NAp
Clays	23.9	44.6	54
Diatomite	1.3	1.5	87
Feldspar	2.5	2.6	96
Gypsum	11.0	16.7	66
Magnesium compounds	18.8	NA	NAp
Nonmetals—Continued			
Mica, scrap	0.6	1.0	60
Perlite	.5	.6	83
Phosphate rock	172.4	182.0	95
Potash	11.0	15.6	71
Pumice	.3	.6	50
Salt:			
Evaporated	4.3	[5]6.2	69
Rock	14.5	15.1	96
Salt in brine	10.6	[5]19.7	54
Sand and gravel:			
Construction	1.1	773.9	([4])
Industrial	13.7	29.4	47
Sodium carbonate, natural	[6]6.7	6.7	100
Stone:			
Crushed	[7]602.2	[5]956.0	63
Dimension	[7].8	[5]1.2	67
Sulfur, Frasch	4.1	[5]4.1	100
Talc	.5	1.0	50
Other nonmetals	[8]4.1	[9]5.4	76
Total or average	905.0	2,085.0	43
Grand total or average	1,279.7	2,561.1	50

NA Not available. NAp Not applicable.
W Withheld to avoid disclosure of company proprietary data; included with other metals.
[1]Excludes gold from base metal ores.
[2]Includes antimony, beryllium, manganiferous ore, mercury, molybdenum, rare earths, tin, titanium, tungsten, and zirconium.
[3]Includes nickel, platinum, and items indicated in footnote 2.
[4]Less than 0.05.
[5]Sold or used by producers or marketable production.
[6]Excludes sodium carbonate from brines.
[7]Estimated based on ratio of respondents' production to total U.S. production (63%) in 1983.
[8]Includes aplite, asbestos, bromine, fluorspar, garnet, iodine, lithium minerals, magnesite and brucite, olivine, pyrophyllite, soapstone, sodium carbonate from brines, sodium sulfate (natural), tripoli, vermiculite, volcanic cinder, and wollastonite.
[9]Includes abrasives, aplite, asbestos, boron minerals, fluorspar, graphite, iron oxide pigments (crude), kyanite, magnesite, marl (greensand), millstones, olivine, pyrophyllite, soapstone, vermiculite, and wollastonite.

Table B-4.—Canvass coverage, by value of mine production, 1984, million dollars

Commodity	Value		Coverage, %
	Respondents	U.S. total	
Metals:			
Bauxite	14.5	15.6	93
Copper	1,294.1	1,608.4	80
Gold:			
Lode	[1]271.6	727.7	37
Placer	12.7	14.8	86
Iron ore	1,926.8	[2]2,247.7	86
Lead	156.8	181.3	86
Silver	223.6	361.8	62
Titanium	W	W	100
Uranium-vanadium[3]	[4]20.2	24.6	82
Zinc	193.5	270.6	71
Other metals	[5]164.9	[6]523.8	31
Total or average	4,278.7	5,976.3	72
Nonmetals:			
Barite	2.8	25.4	11
Calcium chloride	1.6	93.0	12
Clays	533.9	1,037.2	51
Diatomite	116.8	120.9	97
Feldspar	19.4	23.5	83
Gypsum	74.3	113.7	65
Magnesium compounds	W	W	W
Nonmetals—Continued			
Mica, scrap	1.9	7.1	27
Perlite	12.9	16.6	78
Phosphate rock	1,128.2	1,182.2	95
Potash	163.9	241.8	68
Pumice	1.5	4.9	31
Salt:			
Evaporated	225.3	387.2	58
Rock	185.6	188.6	98
Salt in brine	61.6	99.3	62
Sand and gravel:			
Construction	3.6	2,244.0	([7])
Industrial	165.1	377.2	44
Sodium carbonate, natural	513.6	611.0	84
Stone:			
Crushed	[8]2,253.4	3,755.6	60
Dimension	[8]92.9	154.6	60
Sulfur, Frasch	532.5	546.1	98
Talc	12.3	23.3	53
Other nonmetals	[9]222.1	[10]1,077.2	21
Total or average	6,324.7	12,330.4	51
Grand total or average	10,603.4	18,306.7	58

W Withheld to avoid disclosure of company proprietary data; included with other metals or nonmetals.
[1]Excludes gold from base metal ores.
[2]Value of shipments of usable ore.
[3]Vanadium only.
[4]Estimated based on ratio of respondents' crude ore production to total U.S. crude ore production (82%).
[5]Includes antimony, beryllium, manganiferous ore, mercury, molybdenum, rare earths, tin, titanium, tungsten, and zirconium.
[6]Includes antimony, beryllium, iron oxide pigments (crude), magnesium chloride for metals, mercury, rare earths, tin, titanum, and zirconium.
[7]Less than 0.05.
[8]Estimated based on ratio of respondents' value of stone production to total value of U.S. stone production (60%) in 1983.
[9]Includes aplite, asbestos, bromine, fluorspar, garnet, iodine, lithium minerals, magnesite and brucite, magnesium compounds, olivine, pyrophyllite, soapstone, sodium sulfate (natural), tripoli, vermiculite, and wollastonite.
[10]Includes abrasive stones, asbestos, asphalt (native), boron minerals, bromine, emery, fluorspar, garnet, graphite, helium (crude), iodine, kyanite, lithium minerals, magnesite, magnesium compounds, marl (greensand), olivine, peat, pyrites, pyrophyllite, sodium sulfate (natural), staurolite, tripoli, and wollastonite.
[11]Excludes cement and lime.

Table B-5.—Types of response, by commodity and number of respondents, 1984

Commodity	Water use			Closed	Total
	$>10^6$ gal	$<10^6$ gal	None		
Metals:					
Antimony	1	0	0	0	1
Bauxite	1	0	5	0	6
Beryllium	0	0	1	0	1
Copper	18	0	0	2	20
Gold:					
Lode	20	1	0	6	27
Placer	8	5	0	4	17
Iron ore	12	0	4	3	19
Lead	3	5	1	1	10
Manganiferous ore	0	0	2	0	2
Mercury	1	0	0	0	1
Molybdenum	2	0	0	0	2
Platinum	0	0	0	1	1
Rare earths	1	0	0	0	1
Silver	12	2	1	1	16
Tin	1	0	0	0	1
Titanium (ilmenite)	2	0	0	0	2
Tungsten	2	0	0	0	2
Uranium-vanadium	15	9	1	30	55
Zinc	8	1	0	2	11
Zirconium	1	0	0	0	1
Total	108	23	15	50	196
Nonmetals:					
Aplite	1	0	0	0	1
Asbestos	1	0	1	0	2
Barite	1	2	0	1	4
Bromine	2	0	0	0	2
Calcium Chloride	0	1	2	0	3
Clays	38	10	130	3	181
Diatomite	4	1	0	0	5
Feldspar	9	1	0	0	10
Fluorspar	1	0	0	0	1
Garnet	1	0	0	0	1

Commodity	Water use			Closed	Total
	$>10^6$ gal	$<10^6$ gal	None		
Nonmetals-Continued					
Gypsum	4	6	17	0	27
Iodine	1	1	0	0	2
Lithium minerals	1	0	0	0	1
Magnesite and brucite	1	0	0	0	1
Magnesium compounds	4	0	0	1	5
Mica, scrap	3	1	0	0	4
Olivine	1	0	0	0	1
Perlite	1	0	2	0	3
Phosphate rock	27	1	3	4	35
Potash	7	0	0	1	8
Pumice	0	0	3	0	3
Pyrophyllite	1	0	0	0	1
Salt:					
Evaporated	16	3	2	2	23
Rock	4	0	7	2	13
Salt in brine	16	2	4	3	25
Sand and gravel:					
Construction	7	2	1	0	10
Industrial	30	7	4	0	41
Soapstone	0	1	0	0	1
Sodium carbonate, natural	6	0	0	0	6
Sodium sulfate, natural	2	0	0	0	2
Stone:					
Crushed	366	317	680	80	1,443
Dimension	1	3	1	0	5
Sulfur, Frasch	6	0	0	0	6
Talc	2	2	1	0	5
Tripoli	1	0	0	0	1
Vermiculite	2	0	0	0	2
Volcanic cinder	0	2	7	0	9
Wollastonite	0	0	1	0	1
Total	568	363	866	97	1,894
Grand total	676	386	881	147	2,090

Table B-6.—Types of response, by State and number of respondents, 1984

State	Water use			Closed	Total
	$>10^6$ gal	$<10^6$ gal	None		
Alabama	13	11	16	4	44
Alaska	6	3	2	4	15
Arizona	18	3	8	0	29
Arkansas	5	7	18	3	33
California	36	21	39	3	99
Colorado	8	5	9	21	43
Connecticut	2	2	1	0	5
Delaware	1	0	0	0	1
Florida	30	10	24	9	73
Georgia	34	8	12	0	54
Guam[1]	1	0	0	0	1
Hawaii	6	2	8	0	16
Idaho	10	3	6	5	24
Illinois	16	8	61	5	90
Indiana	16	5	26	1	48
Iowa	15	19	30	0	64
Kansas	11	7	28	4	50
Kentucky	14	22	32	3	71
Louisiana	12	4	2	1	19
Maine	1	0	1	0	2
Maryland	9	6	8	0	23
Massachusetts	4	3	7	1	15
Michigan	16	2	12	3	33
Minnesota	14	2	17	1	34
Mississippi	2	2	10	0	14
Missouri	13	18	79	3	113
Montana	6	2	5	1	14
Nebraska	1	2	5	0	8
Nevada	23	3	7	5	38
New Hampshire	NA	NA	NA	NA	0
New Jersey	7	2	9	2	20
New Mexico	14	4	16	5	39
New York	35	8	19	4	66
North Carolina	25	10	15	1	51
North Dakota	1	0	1	0	2
Ohio	21	20	54	3	98
Oklahoma	6	12	23	2	43
Oregon	2	14	19	5	40
Pennsylvania	39	30	39	5	113
Puerto Rico[1]	3	2	11	0	16
Rhode Island	3	1	0	0	1
South Carolina	12	3	13	1	29
South Dakota	1	2	5	0	8
Tennessee	43	20	29	6	98
Texas	58	19	45	11	133
Utah	10	8	5	7	30
Vermont	0	5	4	0	9
Virgin Islands[1]	0	1	0	0	1
Virginia	21	27	16	2	66
Washington	7	7	18	5	37
West Virginia	9	6	14	3	32
Wisconsin	5	4	44	1	54
Wyoming	13	2	9	7	31
Total	676	386	881	147	2,090

NA Not available.
[1]U.S.-administered islands and commonwealth.

Table B-7.—Adequacy of water supply, by commodity, 1984[1]

Commodity	Respondents with adequate supply for—					Need, 10^6 gal
	([2])	5 yr	10 yr	20 yr	([3])	
Metals:						
Antimony	0	0	0	1	0	0
Bauxite	0	0	0	1	0	0
Copper	0	1	5	11	1	0
Gold:						
Lode	1	3	6	8	2	W
Placer	0	0	1	6	1	0
Iron ore	0	1	1	7	3	0
Lead	0	0	3	0	0	0
Mercury	0	0	1	0	0	0
Molybdenum	0	0	0	2	0	0
Rare earths	0	0	0	1	0	0
Silver	0	4	1	6	1	0
Tin	0	0	0	0	1	0
Titanium (ilmenite)	0	0	0	2	0	0
Tungsten	0	0	0	2	0	0
Uranium-vanadium	0	0	0	15	0	0
Zinc	0	0	0	5	3	0
Zirconium	0	0	0	1	0	0
Total	1	9	18	68	12	W
Nonmetals:						
Aplite	0	1	0	0	0	0
Asbestos	0	0	0	1	0	0
Barite	0	1	0	0	0	0
Bromine	0	0	0	2	0	0
Clays	0	6	10	20	2	0
Diatomite	0	0	1	2	1	0
Feldspar	0	2	1	6	0	0
Fluorspar	0	0	0	1	0	0
Garnet	0	0	0	1	0	0
Nonnetals—Continued						
Gypsum	0	0	0	4	0	0
Iodine	0	0	0	1	0	0
Lithium minerals	0	0	0	1	0	0
Magnesite and brucite	1	0	0	0	0	W
Magnesium compounds	0	0	0	3	1	0
Mica, scrap	0	1	1	0	1	0
Olivine	0	0	0	1	0	0
Perlite	0	0	0	1	0	0
Phosphate rock	0	2	4	19	2	0
Potash	0	2	1	4	0	0
Pyrophyllite	0	0	0	1	0	0
Salt:						
Evaporated	0	1	2	13	0	0
Rock	0	0	0	3	1	0
Salt in brine	0	1	3	12	0	0
Sand and gravel:						
Construction	0	0	2	5	0	0
Industrial	0	6	2	21	1	0
Sodium carbonnate, natural	0	1	1	4	0	0
Sodium sulfate, natural	0	0	0	2	0	0
Stone:						
Crushed	5	31	49	263	18	W
Dimension	0	0	0	1	0	0
Sulfur, Frasch	0	1	1	1	3	0
Talc	0	0	0	2	0	0
Tripoli	0	0	1	0	0	0
Vermiculite	0	0	0	1	1	0
Total	6	56	79	396	31	W
Grand total	7	65	97	464	43	206

W Withheld to avoid disclosure of company proprietary data; included in grand total.
[1]As reported by respondents using more than 1 million gal.
[2]Inadequate supply.
[3]Unspecified number of years.

NOTE.—No water use was reported for the following commodities: beryllium, manganiferous ore, platinum, calcium chloride, pumice, soapstone, volcanic cinder, and wollastonite.

Table B-8.—Adequacy of water supply, by State, 1984[1]

State	Respondents with adequate supply for—					Need, 10^6 gal
	([2])	5 yr	10 yr	20 yr	([3])	
Alabama	0	0	1	11	1	0
Alaska	0	0	0	5	1	0
Arizona	0	2	3	12	1	0
Arkansas	0	0	0	5	0	0
California	1	4	4	25	2	W
Colorado	0	0	2	4	2	0
Connecticut	0	0	0	2	0	0
Delaware	0	0	0	0	1	0
Florida	0	3	3	23	1	0
Georgia	0	4	4	26	0	0
Guam[4]	0	0	0	1	0	0
Hawaii	0	0	2	4	0	0
Idaho	0	2	2	6	0	0
Illinois	0	2	2	12	0	0
Indiana	0	0	1	14	1	0
Iowa	0	0	0	13	2	0
Kansas	0	1	4	6	0	0
Kentucky	0	5	1	8	0	0
Louisiana	0	0	2	6	4	0
Maine	0	0	0	1	0	0
Maryland	0	0	3	5	1	0
Massachusetts	0	1	1	2	0	0
Michigan	0	1	1	14	0	0
Minnesota	0	1	0	8	5	0
Mississippi	0	1	0	1	0	0
Missouri	0	0	2	9	2	0
Montana	0	0	1	4	1	0
Nebraska	0	0	0	1	0	0
Nevada	1	7	4	9	2	W
New Hampshire	NA	NA	NA	NA	NA	NA
New Jersey	0	1	1	5	0	0
New Mexico	0	5	3	6	0	0
New York	2	3	7	21	2	W
North Carolina	0	1	4	18	2	0
North Dakota	0	1	0	0	0	0
Ohio	0	1	1	19	0	0
Oklahoma	0	0	0	6	0	0
Oregon	1	0	0	0	1	W
Pennsylvania	1	5	6	26	1	W
Puerto Rico[4]	0	0	0	3	0	0
Rhode Island	0	0	0	1	0	0
South Carolina	0	1	6	3	2	0
South Dakota	0	0	1	0	0	0
Tennessee	0	2	5	34	2	0
Texas	0	7	6	42	3	0
Utah	0	0	0	9	1	0
Virginia	0	1	1	19	0	0
Washington	0	1	2	3	1	0
West Virginia	0	0	2	7	0	0
Wisconsin	0	0	0	4	1	0
Wyoming	1	2	9	1	0	W
Total	7	65	97	464	43	206

NA Not available.
W Withheld to avoid disclosure of company proprietary data; included in total.
[1]As reported by respondents using more than 1 million gal.
[2]Inadequate supply.
[3]Unspecified number of years.
[4]U.S.-administered islands and commonwealth.

NOTE.—No water use was reported for Vermont and the Virgin Islands.

APPENDIX C.—ESTIMATED WATER USE IN THE DOMESTIC NONFUEL MINERALS INDUSTRY IN 1984

Table C-1.—Water use, by commodity and type of water, 1984, million gallons

Commodity	New water	Recirculated water	Total	Water discharged	Water consumed
Metals:					
Copper	81,460	119,900	201,360	18,870	62,590
Gold:					
Lode	6,220	8,960	15,180	1,980	4,240
Placer	3,490	5,310	8,800	3,240	250
Iron ore	67,740	584,350	652,090	57,020	10,720
Lead	2,500	320	2,820	2,470	30
Silver	2,490	1,020	3,510	1,480	1,010
Uranium-vanadium	6,980	1,440	8,420	5,960	1,020
Zinc	2,400	1,590	3,990	1,890	510
Other metals[1]	6,250	39,910	46,160	3,770	2,480
Total	179,530	762,800	942,330	96,680	82,850
Nonmetals:					
Clays	22,600	8,480	31,080	14,810	7,790
Diatomite	520	150	670	0	520
Feldspar	1,430	8,190	9,620	1,080	350
Gypsum	560	80	640	30	530
Magnesium compounds	960	720	1,680	960	0
Mica, scrap	1,140	480	1,620	730	410
Phosphate rock	117,690	660,790	778,480	56,840	60,850
Potash	4,400	3,090	7,490	2,240	2,160
Salt:					
Evaporated	22,580	7,880	30,460	20,590	1,990
Rock	3,570	3,890	7,460	3,400	170
Salt in brine	6,310	0	6,310	0	6,310
Sand and gravel:					
Construction	100,500	45,350	145,850	67,720	32,780
Industrial	23,710	84,990	108,700	7,620	16,090
Sodium carbonate, natural	9,480	27,090	36,570	3,560	5,920
Stone: Crushed	64,960	61,100	126,060	45,640	19,320
Sulfur, Frasch	7,550	5,200	12,750	5,550	2,000
Other nonmetals[2]	3,510	15,620	19,130	800	2,710
Total	391,470	933,100	1,324,570	231,570	159,900
Grand total	571,000	1,695,900	2,266,900	328,250	242,750

[1]Includes antimony, bauxite, mercury, molybdenum, rare earths, tin, titanium, tungsten, and zirconium.
[2]Includes aplite, asbestos, barite, fluorspar, garnet, iodine, lithium minerals, magnesite and brcite, olivine, perlite, pyrophyllite, sodium sulfate (natural), dimension stone, talc, tripoli, and vermiculite.

Table C-2.—Water use, by commodity and type of operation, 1984, million gallons

Commodity	Mining	Processing	Other	Total
Metals:				
Copper	14,680	184,780	1,900	201,360
Gold:				
Lode	1,370	10,100	3,710	15,180
Placer	1,740	6,860	200	8,800
Iron ore	3,030	649,020	40	652,090
Lead	50	2,750	20	2,820
Silver	870	1,670	970	3,510
Uranium-vanadium	6,200	1,870	350	8,420
Zinc	1,660	2,280	50	3,990
Other metals[1]	24,750	21,360	50	46,160
Total	54,350	880,690	7,290	942,330
Nonmetals:				
Clays	1,310	27,160	2,610	31,080
Diatomite	0	470	200	670
Feldspar	20	9,440	160	9,620
Gypsum	220	340	80	640
Magnesium compounds	0	1,640	40	1,680
Mica, scrap	0	1,620	0	1,620
Phosphate rock	74,840	687,620	16,020	778,480
Potash	130	7,330	30	7,490
Salt:				
Evaporated	5,200	22,220	3,040	30,460
Rock	1,930	5,430	100	7,460
Salt in brine	5,050	0	1,260	6,310
Sand and gravel:				
Construction	21,320	101,070	23,460	145,850
Industrial	34,540	58,670	15,490	108,700
Sodium carbonate, natural	40	36,530	0	36,570
Stone: Crushed	13,190	100,400	12,470	126,060
Sulfur, Frasch	11,130	260	1,360	12,750
Other nonmetals[2]	50	18,640	440	19,130
Total	168,970	1,078,840	76,760	1,324,570
Grand total	223,320	1,959,530	84,050	2,266,900

[1]Includes antimony, bauxite, mercury, molybdenum, rare earths, tin, titanium, tungsten, and zirconium.
[2]Includes aplite, asbestos, barite, fluorspar, garnet, iodine, lithium minerals, magnesite and brcite, olivine, perlite, pyrophyllite, sodium sulfate (natural), dimension stone, talc, tripoli, and vermiculite.

Table C-3.—Sources of new water, by commodity, 1984, million gallons

Commodity	Stream or river	Lake or reservoir	Mine water	Ground water	Other	Total
Metals:						
Copper	17,730	4,040	6,770	49,780	3,140	81,460
Gold:						
Lode	830	10	250	5,100	30	6,220
Placer	2,110	0	0	1,380	0	3,490
Iron ore	8,140	51,860	6,970	110	660	67,740
Lead	0	0	2,180	300	20	2,500
Silver	1,160	10	640	410	270	2,490
Uranium-vanadium	90	70	5,730	1,090	0	6,980
Zinc	170	150	1,380	0	700	2,400
Other metals[1]	630	0	1,730	3,870	20	6,250
Total	30,860	56,140	25,650	62,040	4,840	179,530
Nonmetals:						
Clays	2,340	320	1,870	17,830	240	22,600
Diatomite	20	10	0	490	0	520
Feldspar	770	310	60	60	230	1,430
Gypsum	0	350	40	170	0	560
Magnesium compounds	330	0	0	620	10	960
Mica, scrap	1,140	0	0	0	0	1,140
Phosphate rock	2,920	0	12,570	68,690	33,510	117,690
Potash	380	0	10	4,000	10	4,400
Salt:						
Evaporated	4,170	12,220	110	5,490	590	22,580
Rock	2,630	40	0	880	20	3,570
Salt in brine	2,150	50	0	4,030	80	6,310
Sand and gravel:						
Construction	20,100	22,110	39,200	15,080	4,010	100,500
Industrial	7,280	10,950	50	2,370	3,060	23,710
Sodium carbonate, natural	3,500	0	10	2,070	3,900	9,480
Stone: Crushed	13,100	7,630	17,660	16,940	9,630	64,960
Sulfur, Frasch	3,350	0	0	2,030	2,170	7,550
Other non-metals[2]	1,090	20	570	1,820	10	3,510
Total	65,270	54,010	72,150	142,570	57,470	391,470
Grand total	96,130	110,150	97,800	204,610	62,310	571,000

[1]Includes antimony, bauxite, mercury, molybdenum, rare earths, tin, titanium, tungsten, and zirconium.
[2]Includes aplite, asbestos, barite, fluorspar, garnet, iodine, lithium minerals, magnesite and brcite, olivine, perlite, pyrophyllite, sodium sulfate (natural), dimension stone, talc, tripoli, and vermiculite.

Table C-4.—Types of water treated, by commodity, 1984, million gallons

Commodity	New water	Recirculated water	Discharge water	Total treated
Metals:				
Copper	40,310	99,620	7,740	147,670
Gold:				
Lode	1,700	3,960	270	5,930
Placer	560	1,780	2,130	4,470
Iron ore	5,760	469,290	16,990	492,040
Lead	2,500	320	2,470	5,290
Silver	1,040	130	1,040	2,210
Uranium-vanadium	6,400	1,050	2,300	9,750
Zinc	1,490	1,520	1,840	4,850
Other metals[1]	2,170	760	3,080	6,010
Total	61,930	578,430	37,860	678,220
Nonmetals:				
Clays	12,220	3,850	13,560	29,630
Diatomite	420	150	0	570
Feldspar	520	8,090	560	9,170
Gypsum	0	10	0	10
Magnesium compounds	780	20	210	1,010
Mica, scrap	0	480	570	1,050
Phosphate rock	36,790	559,570	39,360	635,720
Potash	530	320	440	1,290
Salt:				
Evaporated	2,540	1,010	1,490	5,040
Rock	300	0	210	510
Salt in brine	1,510	0	0	1,510
Sand and gravel:				
Construction	5,030	22,680	40,630	68,340
Industrial	14,710	76,070	7,290	98,070
Sodium carbonate, natural	7,530	17,870	3,300	28,700
Stone: Crushed	20,640	46,820	22,220	89,680
Sulfur, Frasch	7,260	5,200	5,050	17,510
Other nonmetals[2]	770	7,380	20	8,170
Total	111,550	749,520	134,910	995,980
Grand total	173,480	1,327,950	172,770	1,674,200

[1]Includes antimony, bauxite, mercury, molybdenum, rare earths, tin, titanium, tungsten, and zirconium.
[2]Includes aplite, asbestos, barite, fluorspar, garnet, iodine, lithium minerals, magnesite and brcite, olivine, perlite, pyrophyllite, sodium sulfate (natural), dimension stone, talc, tripoli, and vermiculite.

Table C-5.—Water use per short ton of crude ore produced in 1984, gallons

Commodity	New water	Recirculated water	Total	Water discharged	Water consumed
Metals:					
Copper	422	621	1,043	98	324
Gold:					
Lode	154	221	375	49	105
Placer	411	625	1,036	381	30
Iron ore	385	3,320	3,705	324	61
Lead	446	57	503	441	5
Silver	315	129	444	187	128
Uranium-vanadium	2,493	514	3,007	2,129	364
Zinc	414	274	688	326	88
Other metals[1]	179	1,144	1,323	108	71
Average	377	1,602	1,979	203	174
Nonmetals:					
Clays	507	190	697	332	175
Diatomite	347	100	447	0	347
Feldspar	550	3,150	3,700	415	135
Gypsum	34	5	39	2	32
Mica, scrap	1,140	480	1,620	730	410
Phosphate rock	647	3,631	4,278	312	335
Potash	282	198	480	144	138
Salt:					
Evaporated	3,642	1,271	4,913	3,321	321
Rock	236	258	494	220	11
Salt in brine	320	0	320	0	320
Sand and gravel:					
Construction	130	59	189	88	42
Industrial	806	2,891	3,697	259	547
Sodium carbonate, natural	1,415	4,043	5,458	531	884
Stone: Crushed	68	64	132	48	20
Sulfur, Frasch	1,841	1,268	3,109	1,354	487
Other nonmetals[2]	650	3,893	3,542	148	502
Average[3]	188	448	636	111	77
Average, all nonfuel minerals	223	662	885	128	95

[1]Includes antimony, bauxite, mercury, molybdenum, rare earths, tin, titanium, tungsten, and zirconium.
[2]Includes aplite, asbestos, barite, fluorspar, garnet, iodine, lithium minerals, magnesite and brucite, olivine, perlite, pyrophyllite, sodium sulfate (natural), dimension stone, talc, tripoli, and vermiculite.
[3]Excludes magnesium compounds, for which value of mine production is withheld.

Table C-6.—Water use per dollar of mine production in 1984, gallons

Commodity	New water	Recirculated water	Total	Water discharged	Water consumed
Metals:					
Copper	51	75	126	12	39
Gold:					
Lode	9	12	21	3	6
Placer	236	359	595	219	17
Iron ore	30	260	290	25	5
Lead	14	2	16	14	0
Silver	7	3	10	4	3
Uranium-vanadium	284	59	343	242	42
Zinc	9	6	15	7	2
Other metals[1]	12	74	86	7	5
Average	30	128	158	16	14
Nonmetals:					
Clays	22	8	30	14	8
Diatomite	4	1	5	0	4
Feldspar	61	349	410	46	15
Gypsum	5	1	6	0	5
Mica, scrap	161	68	229	103	58
Phosphate rock	100	559	659	48	52
Potash	18	13	31	9	9
Salt:					
Evaporated	58	20	78	53	5
Rock	19	21	40	18	1
Salt in brine	64	0	64	0	64
Sand and gravel:					
Construction	45	20	65	30	15
Industrial	63	225	288	20	43
Sodium carbonate, natural	16	44	60	6	10
Stone: Crushed	17	16	33	12	5
Sulfur, Frasch	14	10	24	10	4
Other nonmetals[2]	3	15	18	1	2
Average[3]	32	76	108	19	13
Average, all nonfuel minerals	31	93	124	18	13

[1]Includes antimony, bauxite, mercury, molybdenum, rare earths, tin, titanium, tungsten, and zirconium.
[2]Includes aplite, asbestos, barite, fluorspar, garnet, iodine, lithium minerals, magnesite and brucite, olivine, perlite, pyrophyllite, sodium sulfate (natural), dimension stone, talc, tripoli, and vermiculite.
[3]Excludes magnesium compounds, for which value of mine production is withheld.

Table C-7.—Water use, by State and type of water, 1984, million gallons

State	New water	Recirculated water	Total	Water discharged	Water consumed
Alabama	5,410	3,430	8,840	2,290	3,120
Alaska	6,250	3,040	9,290	4,920	1,330
Arizona	47,410	76,360	123,770	7,160	40,250
Arkansas	1,900	1,100	3,000	1,100	800
California	23,990	47,890	71,880	15,400	8,590
Colorado	4,350	2,320	6,670	3,060	1,290
Connecticut	1,140	650	1,790	840	300
Delaware	260	60	320	220	40
Florida	110,430	615,460	725,890	46,710	63,720
Georgia	22,740	15,480	38,220	14,640	8,100
Guam[1]	150	0	150	150	0
Hawaii	780	500	1,280	660	120
Idaho	2,440	3,630	6,070	1,770	670
Illinois	13,610	30,510	44,120	9,020	4,590
Indiana	3,660	2,180	5,840	2,930	730
Iowa	2,650	2,760	5,410	2,010	640
Kansas	7,290	3,750	11,040	5,850	1,440
Kentucky	1,850	710	2,560	1,470	380
Louisiana	12,460	7,130	19,590	8,650	3,810
Maine	1,030	480	1,510	690	340
Maryland	2,380	860	3,240	1,560	820
Massachusetts	2,500	910	3,410	1,860	640
Michigan	26,910	208,720	235,630	23,170	3,740
Minnesota	65,000	383,850	448,850	53,580	11,420
Mississippi	2,010	720	2,730	1,440	570
Missouri	7,630	3,970	11,600	6,550	1,080
Montana	2,690	4,420	7,110	720	1,970
Nebraska	1,550	690	2,240	1,040	510
Nevada	10,450	13,750	24,200	2,950	7,500
New Hampshire	730	330	1,060	490	240
New Jersey	8,670	10,340	19,010	1,250	7,420
New Mexico	18,300	29,320	47,620	9,760	8,540
New York	18,200	7,450	25,650	14,150	4,050
North Carolina	27,320	106,020	133,340	20,260	7,060
North Dakota	830	390	1,220	560	270
Ohio	9,220	6,990	16,210	6,680	2,540
Oklahoma	1,580	1,170	2,570	970	610
Oregon	1,670	750	2,420	1,130	540
Pennsylvania	11,240	5,650	16,890	8,960	2,280
Puerto Rico[1]	80	760	840	20	60
Rhode Island	220	100	320	160	60
South Carolina	2,740	2,890	5,630	1,530	1,210
South Dakota	760	570	1,330	510	250
Tennessee	14,960	12,290	27,250	13,310	1,650
Texas	19,310	34,450	53,760	9,800	9,510
Utah	26,680	21,450	48,130	6,590	20,090
Vermont	490	220	710	330	160
Virgin Islands[1]	0	0	0	0	0
Virginia	2,280	5,540	7,820	1,340	940
Washington	3,610	1,610	5,220	2,550	1,060
West Virginia	1,330	70	1,400	600	730
Wisconsin	2,820	1,510	4,330	1,990	830
Wyoming	7,040	10,700	17,140	2,900	4,140
Total	571,000	1,695,900	2,266,900	328,250	242,750

[1]U.S.-administered islands and commonwealth.

Table C-8.—Water use, by State and type of operation, 1984, million gallons

State	Mining	Processing	Other	Total
Alabama	2,930	4,000	1,910	8,840
Alaska	2,910	5,440	940	9,290
Arizona	4,290	117,870	1,610	123,770
Arkansas	230	2,520	250	3,000
California	7,140	61,000	3,740	71,880
Colorado	830	4,970	870	6,670
Connecticut	180	1,390	220	1,790
Delaware	30	260	30	320
Florida	104,030	603,870	17,990	725,890
Georgia	5,540	29,830	2,850	38,220
Guam[1]	0	150	0	150
Hawaii	20	1,240	20	1,280
Idaho	670	4,850	550	6,070
Illinois	9,300	27,450	7,370	44,120
Indiana	1,460	3,490	890	5,840
Iowa	1,150	2,840	420	5,410
Kansas	3,270	7,160	610	11,040
Kentucky	240	2,010	310	2,560
Louisiana	6,570	11,490	1,530	19,590
Maine	220	1,050	240	1,510
Maryland	390	2,380	470	3,240
Massachusetts	390	1,970	1,050	3,410
Michigan	2,340	231,800	1,490	235,630
Minnesota	7,920	440,190	740	448,850
Mississippi	940	2,000	390	2,730
Missouri	270	9,960	1,370	11,600
Montana	430	6,070	610	7,110
Nebraska	330	1,550	360	2,240
Nevada	3,130	17,800	3,270	24,200
New Hampshire	150	730	180	1,060
New Jersey	4,670	8,940	5,400	19,010
New Mexico	4,290	41,800	1,530	47,620
New York	6,580	14,460	4,610	25,650
North Carolina	1,130	130,600	1,610	133,340
North Dakota	190	840	190	1,220
Ohio	2,230	12,490	1,490	16,210
Oklahoma	310	1,900	540	2,750
Oregon	350	1,680	390	2,420
Pennsylvania	1,740	14,320	830	16,890
Puerto Rico[1]	90	750	0	840
Rhode Island	40	230	50	320
South Carolina	390	4,590	650	5,630
South Dakota	160	1,000	170	1,330
Tennessee	11,520	13,330	2,400	27,250
Texas	16,740	30,220	6,800	53,760
Utah	2,530	45,100	500	48,130
Vermont	100	490	120	710
Virgin Islands[1]	0	0	0	0
Virginia	520	7,020	280	7,820
Washington	640	3,750	830	5,220
West Virginia	840	520	40	1,400
Wisconsin	490	3,300	540	4,330
Wyoming	1,480	16,120	140	17,740
Total	223,320	1,959,530	84,050	2,266,900

[1]U.S.-administered islands and commonwealth.

Table C-9—Sources of new water by State, 1984, million gallons

State	Stream or river	Lake or reservoir	Mine water	Ground water	Other	Total
Alabama	520	1,950	2,370	260	310	5,410
Alaska	3,220	1,140	1,060	680	150	6,250
Arizona	9,850	880	3,790	28,880	4,010	47,410
Arkansas	230	240	420	930	80	1,900
California	2,770	3,010	6,800	6,570	4,840	23,990
Colorado	930	800	1,920	560	140	4,350
Connecticut	430	190	340	130	50	1,140
Delaware	160	30	50	20	0	260
Florida	1,640	600	12,260	54,160	41,770	110,430
Georgia	2,600	1,680	2,020	16,230	210	22,740
Guam[1]	0	0	0	0	150	150
Hawaii	110	60	20	530	60	780
Idaho	1,320	130	390	520	80	2,440
Illinois	7,490	750	2,760	2,150	460	13,610
Indiana	560	500	1,360	410	830	3,660
Iowa	370	400	1,060	750	70	2,650
Kansas	1,210	360	740	4,930	50	7,290
Kentucky	250	220	430	890	60	1,850
Louisiana	6,780	490	860	2,040	2,290	12,460
Maine	210	220	400	150	50	1,030
Maryland	390	410	890	550	140	2,380
Massachusetts	380	430	720	900	70	2,500
Michigan	11,480	11,220	2,770	1,250	190	26,910
Minnesota	750	51,620	11,270	550	810	65,000
Mississippi	320	350	620	640	80	2,010
Missouri	3,300	250	3,260	730	90	7,630
Montana	860	10	1,300	250	270	2,690
Nebraska	310	340	600	240	60	1,550
Nevada	1,450	980	640	7,340	40	10,450
New Hampshire	150	160	280	110	30	730
New Jersey	290	7,070	630	200	480	8,670
New Mexico	850	3,900	8,660	4,770	120	18,300
New York	2,810	10,690	2,230	2,180	290	18,200
North Carolina	1,260	330	1,690	23,790	250	27,320
North Dakota	170	180	320	120	40	830
Ohio	2,950	1,120	3,060	1,860	230	9,220
Oklahoma	300	410	560	250	60	1,580
Oregon	330	370	650	260	60	1,670
Pennsylvania	1,410	450	6,560	2,670	150	11,240
Puerto Rico[1]	0	0	0	80	0	80
Rhode Island	70	40	70	30	10	220
South Carolina	930	170	1,020	210	410	2,740
South Dakota	150	170	290	120	30	760
Tennessee	11,980	610	1,190	370	810	14,960
Texas	3,380	2,580	4,000	8,160	1,190	19,310
Utah	1,680	440	770	23,360	430	26,680
Vermont	100	110	190	70	20	490
Virgin Islands[1]	0	0	0	0	0	0
Virginia	770	250	550	650	60	2,280
Washington	620	1,170	1,190	520	110	3,610
West Virginia	700	30	50	550	0	1,330
Wisconsin	860	510	910	450	90	2,820
Wyoming	4,480	130	1,810	590	30	7,040
Total	96,130	110,150	97,800	204,610	62,310	571,000

[1]U.S.-administered islands and commonwealth.

Table C-10.—Types of water treated, by State, 1984, million gallons

State	New water	Recirculated water	Discharge water	Total treated
Alabama	3,370	3,110	1,880	8,360
Alaska	270	2,140	3,830	6,240
Arizona	36,090	54,250	1,600	91,940
Arkansas	60	860	440	1,360
California	8,140	39.050	10.150	57,340
Colorado	750	1,470	1,970	4,190
Connecticut	40	380	590	1,010
Delaware	140	30	180	350
Florida	45,500	593,740	41,040	680,280
Georgia	1,320	12,840	12,660	26,820
Guam[1]	0	0	0	0
Hawaii	50	180	130	360
Idaho	1,220	2,800	1,240	5,370
Illinois	2,400	23,610	6,150	32,160
Indiana	420	920	2,030	3,370
Iowa	710	2,310	760	3,780
Kansas	240	1,170	650	2,060
Kentucky	840	400	1,190	2,430
Louisiana	6,400	710	5,310	12,420
Maine	60	250	410	720
Maryland	100	440	1,050	1,590
Massachusetts	90	490	770	1,350
Michigan	6,520	204,490	15,080	226,090
Minnesota	6,060	254,110	10,140	270,310
Mississippi	310	360	970	1,640
Missouri	4,530	940	5,980	11,450
Montana	70	3,370	410	3,850
Nebraska	80	350	620	1,050
Nevada	1,800	8,410	500	10,710
New Hampshire	40	170	290	500
New Jersey	6,870	4,660	630	12,160
New Mexico	10,580	26,130	4,190	40,900
New York	3,070	3,860	3,540	10,470
North Carolina	1,950	9,260	6,390	17,600
North Dakota	40	190	340	570
Ohio	1,380	5,610	2,690	9,680
Oklahoma	80	810	590	1,480
Oregon	80	380	680	1,140
Pennsylvania	3,520	2,960	4,860	11,340
Puerto Rico[1]	0	720	0	720
Rhode Island	10	50	80	140
South Carolina	10	2,650	690	3,450
South Dakota	40	170	310	520
Tennessee	1,850	6,300	2,400	10,550
Texas	5,810	26,470	5,150	37,430
Utah	5,750	20,850	5,810	32,410
Vermont	20	110	200	330
Virgin Islands[1]	0	0	0	0
Virginia	290	690	710	1,690
Washington	260	800	1,730	2,790
West Virginia	390	30	530	950
Wisconsin	150	970	950	2,070
Wyoming	3,500	930	2,280	6,710
Total	173,480	1,327,950	172,770	1,674,200

[1]U.S.-administered islands and commonwealth.

APPENDIX D.—WATER USE TRENDS, 1954-84

Table D-1.—New water intake, by commodity, billion gallons

Commodity	1954	1962	1968	1973	1978	1983	1984
Metals:							
Copper	59.0	81.0	109.0	138.1	80.4	89.7	81.5
Gold and silver	17.0	[1]54.6	6.0	W	5.5	7.3	12.2
Iron ore	27.0	112.6	340.0	355.9	326.0	45.7	67.7
Lead and zinc	22.0	22.9	17.0	19.4	19.7	W	4.9
Uranium-vanadium	2.0	7.2	7.0	8.0	7.1	10.5	7.0
Other metals	11.0	NA	20.0	22.3	13.7	17.0	6.3
Total	138.0	NAp	499.0	543.7	452.4	170.2	179.5
Nonmetals:							
Clays	7.0	7.1	11.0	14.2	W	19.4	22.6
Phosphate rock	63.0	117.2	247.0	149.8	100.9	60.2	117.7
Potash, soda, borates	11.0	7.3	9.0	21.3	16.9	26.9	[2]13.9
Rock salt	3.0	[3]28.9	6.0	10.9	6.4	NA	3.6
Sand and gravel[4]	187.0	217.6	127.0	122.9	133.9	123.1	124.2
Stone[5]	60.0	53.6	50.0	48.3	42.6	47.8	[6]65.0
Sulfur	16.0	17.6	24.0	13.8	23.4	NA	7.6
Other nonmetals	22.0	NA	9.0	30.9	78.0	100.4	37.0
Total	369.0	NAp	483.0	412.1	402.1	377.8	391.5
Grand total	507.0	[7]757.7	982.0	955.8	854.5	548.0	571.0

NA Not available. NAp Not applicable.
W Withheld to avoid disclosure of company proprietary data; included in grand total.
[1]Gold only.
[2]Potash and sodium carbonate (natural) only.
[3]Possibly includes evaporated salt.
[4]Construction and industrial sand and gravel.
[5]Crushed and dimension stone.
[6]Crushed stone only.
[7]Includes other metals and nonmetals.

Table D-2.—Recirculated water, by commodity, billion gallons

Commodity	1954	1962	1968	1973	1978	1983	1984
Metals:							
Copper	24.0	93.6	338.0	358.3	311.1	133.7	119.9
Gold and silver	8.0	[1]4.2	5.0	W	4.4	5.0	15.3
Iron ore	33.0	139.5	319.0	493.8	423.7	375.9	584.4
Lead and zinc	16.0	1.9	4.0	5.8	10.0	W	1.9
Uranium-vanadium	0	1.0	4.0	3.2	W	5.0	1.4
Other metals	22.0	NA	33.0	48.4	65.1	44.7	39.9
Total	103.0	NAp	703.0	909.5	814.3	564.3	762.8
Nonmetals:							
Clays	2.0	1.6	2.0	W	W	8.2	8.5
Phosphate rock	75.0	269.3	308.0	299.2	261.6	429.3	660.8
Potash, soda, borates	15.0	35.6	48.0	28.8	171.0	98.6	[2]30.9
Rock salt	0	[3]8.8	4.0	W	W	W	3.9
Sand and gravel[4]	74.0	122.7	51.0	93.6	90.1	78.3	130.3
Stone[5]	6.0	16.5	8.0	10.2	23.5	16.6	[6]61.6
Sulfur	1.0	.2	2.0	W	W	NA	5.2
Other nonmetals	45.0	NA	4.0	10.8	24.5	9.2	33.1
Total	218.0	NAp	427.0	442.6	570.7	640.2	933.1
Grand total	321.0	[7]728.9	1,130.0	1,352.1	1,385.0	1,204.5	1,695.9

NA Not available. NAp Not applicable.
W Withheld to avoid disclosure of company proprietary data; included in other metals or nonmetals.
[1]Gold only.
[2]Potash and sodium carbonate (natural) only.
[3]Possibly includes evaporated salt.
[4]Construction and industrial sand and gravel.
[5]Crushed and dimension stone.
[6]Crushed stone only.
[7]Includes other metals and nonmetals.

Table D-3.—Total water used, by commodity, billion gallons

Commodity	1954	1962	1968	1973	1978	1983	1984
Metals:							
Copper	83.0	174.6	447.0	496.4	391.5	223.4	201.4
Gold and silver	25.0	[1]58.8	11.0	10.9	9.9	12.3	27.5
Iron ore	60.0	252.1	659.0	849.7	749.7	421.6	652.1
Lead and zinc	38.0	24.8	21.0	25.2	19.7	W	6.8
Uranium-vanadium	2.0	8.2	11.0	11.2	W	15.5	8.4
Other metals	33.0	NA	53.0	59.8	85.9	61.7	46.2
Total	241.0	NAp	1,202.0	1,453.2	1,266.7	734.5	942.3
Nonmetals:							
Clays	9.0	8.7	13.0	W	W	27.6	31.1
Phosphate rock	138.0	386.5	555.0	449.0	362.5	489.5	778.5
Potash, soda, borates	26.0	42.9	57.0	50.1	187.9	125.5	[2]44.1
Rock salt	3.0	[3]37.7	10.0	W	W	W	7.5
Sand and gravel[4]	261.0	340.3	178.0	216.5	224.0	201.4	254.5
Stone[5]	66.0	70.1	58.0	58.5	66.1	64.4	[6]126.1
Sulfur	17.0	17.8	26.0	W	W	NA	12.8
Other nonmetals	67.0	NA	13.0	80.6	132.3	109.6	70.1
Total	587.0	NAp	910.0	854.7	972.8	1,018.0	1,324.6
Grand total	828.0	[7]1,486.6	2,112.0	2,307.9	2,239.5	1,752.5	2,669.9

NA Not available. NAp Not applicable.
W Withheld to avoid disclosure of company proprietary data; included in other metals or nonmetals.
[1]Gold only.
[2]Potash and sodium carbonate (natural) only.
[3]Possibly includes evaporated salt.
[4]Construction and industrial sand and gravel.
[5]Crushed and dimension stone.
[6]Crushed stone only.
[7]Includes other metals and nonmetals.

Table D-4.—Crude ore production, by commodity, million short tons

Commodity	1954	1962	1968	1973	1978	1983	1984
Metals:							
Copper	93.7	151.1	173.9	320.0	262.0	196.0	193.0
Gold and silver	NA	[1]48.9	12.4	6.4	7.5	49.8	56.9
Iron ore	122.0	164.8	216.4	244.0	262.0	128.0	176.0
Lead and zinc	NA	13.5	19.3	16.0	16.0	14.1	11.4
Uranium-vanadium	0.9	7.1	5.9	6.0	16.5	10.2	2.8
Other metals	NA	37.6	53.1	62.6	64.0	28.9	36.0
Total	NAp	423.0	481.0	655.0	628.0	427.0	476.1
Nonmetals:							
Clays	[2]42.4	48.5	62.8	58.7	52.3	40.6	44.6
Phosphate rock	51.0	63.3	146.6	138.0	191.0	141.0	182.0
Potash, soda, borates	NA	17.6	36.5	[3]23.5	[3]30.5	[3]20.5	[3]22.3
Rock salt	[2]4.8	[4]28.8	18.4	12.9	18.2	10.1	15.1
Sand and gravel[5]	[2]553.7	776.7	810.5	984.0	997.0	681.7	803.3
Stone[6]	[2]404.6	687.7	824.7	1,052.7	1,074.2	870.6	[7]956.0
Sulfur	6.4	5.7	8.4	[2]8.3	[2]6.3	[2]4.5	[2]4.1
Other nonmetals	NA	26.8	40.1	50.2	46.8	47.2	57.6
Total[8]	NAp	1,655.1	1,948.0	2,328.3	2,416.3	1,816.2	2,085.0
Grand total	NAp	2,078.1	2,429.0	2,983.3	3,044.3	2,243.2	2,561.1

NA Not available. NAp Not applicable.
[1]Gold only.
[2]Marketable product.
[3]Potash and sodium carbonate (natural) only.
[4]Possibly includes evaporated salt.
[5]Construction and industrial sand and gravel.
[6]Crushed and dimension stone.
[7]Crushed stone only.
[8]Excludes cement and lime.

Table D-5.—Value of mine production, by commodity, million 1984 dollars

Commodity	1954	1962	1968	1973	1978	1983	1984
Metals:							
Copper	2,026.1	2,564.3	2,890.9	4,464.4	2,979.5	1,824.0	1,608.4
Gold and silver	365.9	[1]183.0	367.6	462.5	607.9	1,381.1	1,104.3
Iron ore	2,161.3	2,095.0	2,398.3	2,541.3	3,575.4	2,018.8	2,247.7
Lead and zinc	786.5	542.2	682.1	861.3	898.9	485.2	451.9
Uranium-vanadium	NA	531.7	590.1	414.6	[2]85.0	[2]31.9	[2]24.6
Other metals	850.3	647.7	812.5	771.8	1,279.9	337.8	539.4
Total	6,190.1	6,563.9	7,705.5	9,525.9	9,426.6	6,078.8	5,976.3
Nonmetals:							
Clays	506.4	552.4	708.0	773.3	1,074.0	969.7	1,037.2
Phosphate rock	356.4	455.1	718.9	521.3	1,390.6	1,063.4	1,182.2
Potash, soda, borates	476.0	601.9	603.0	725.5	1,355.9	1,441.9	[3]852.8
Rock salt	116.3	[4]592.5	229.1	171.4	225.8	143.9	188.6
Sand and gravel[5]	2,041.6	2,693.1	2,925.0	2,968.7	3,446.6	2,364.8	2,621.2
Stone[6]	2,490.8	3,475.8	3,778.9	4,346.9	4,320.6	3,618.8	[7]3,755.6
Sulfur	583.7	367.7	769.0	302.7	419.1	431.4	546.1
Other nonmetals	631.2	655.4	1,461.8	1,365.8	1,732.2	1,425.4	2,146.7
Total[8]	7,202.4	9,393.9	11,193.7	11,175.6	13,964.8	11,459.3	12,330.4
Grand total	13,392.5	15,957.8	18,899.2	20,701.5	23,391.4	17,538.1	18,306.7

NA Not available.
[1]Gold only.
[2]Vanadium only.
[3]Potash and sodium carbonate (natural) only.
[4]Possibly includes evaporated salt.
[5]Construction and industrial sand and gravel.
[6]Crushed and dimension stone.
[7]Crushed stone only.
[8]Excludes cement and lime.

Table D-6.—New water intake per short ton of crude ore production, gallons

Commodity	1954	1962	1968	1973	1978	1983	1984
Metals:							
Copper	630	536	627	432	307	458	422
Gold and silver	NAp	[1]1,117	484	NAp	733	147	214
Iron ore	221	683	1,571	1,459	1,244	357	385
Lead and zinc	NAp	1,696	881	1,213	1,231	NAp	430
Uranium-vanadium	2,222	1,014	1,186	1,333	430	1,029	2,500
Other metals	NAp	NAp	377	356	214	588	175
Average	NAp	NAp	1,037	830	720	399	377
Nonmetals:							
Clays	[2]165	146	175	242	NAp	NAp	507
Phosphate rock	1,235	1,852	1,685	1,086	528	427	647
Potash, soda, borates	NAp	415	247	[3]906	[3]554	[3]1,312	[3]623
Rock salt	[2]625	[4]1,003	326	845	352	NAp	238
Sand and gravel[5]	[2]338	280	157	125	134	181	155
Stone[6]	[2]148	78	61	46	40	55	[7]68
Sulfur	2,500	3,088	2,857	[2]1,663	[2]3,714	NAp	[2]1,854
Other nonmetals	NAp	NAp	265	676	1,853	2,576	642
Average	NAp	NAp	248	177	166	208	188
Average, all nonfuel minerals	NAp	365	404	320	281	244	223

NAp Not applicable.
[1]Gold only.
[2]Marketable production.
[3]Potash and sodium carbonate (natural) only.
[4]Possibly includes evaporated salt.
[5]Construction and industrial sand and gravel.
[6]Crushed and dimension stone.
[7]Crushed stone only.

Table D-7.—Recirculated water per short ton of crude ore production, gallons

Commodity	1954	1962	1968	1973	1978	1983	1984
Metals:							
Copper	256	619	1,944	1,120	1,187	628	621
Gold and silver	NAp	[1]86	403	NAp	587	100	269
Iron ore	270	846	1,474	2,024	1,617	2,937	3,320
Lead and zinc	NAp	141	207	363	625	NAp	167
Uranium-vanadium	0	141	678	533	NAp	490	500
Other metals	NAp	NAp	621	773	1,017	1,547	1,108
Average	NAp	NAp	1,462	1,389	1,297	1,322	1,602
Nonmetals:							
Clays	[2]47	33	32	NAp	NAp	NAp	190
Phosphate rock	1,471	4,254	2,101	2,168	1,370	3,045	3,630
Potash, soda, borates	NAp	2,023	1,315	[3]1,226	[3]5,607	[3]4,810	[3]1,354
Rock salt	0	[4]306	217	NAp	NAp	NAp	258
Sand and gravel[5]	[2]134	158	63	95	90	115	162
Stone[6]	[2]15	24	10	10	22	19	[7]64
Sulfur	156	35	238	NAp	NAp	NAp	[2]1,268
Other nonmetals	NAp	NAp	118	236	582	374	575
Average	NAp	NAp	219	190	236	352	448
Average, all nonfuel minerals	NAp	351	465	453	455	537	662

NAp Not applicable.
[1]Gold only.
[2]Marketable production.
[3]Potash and sodium carbonate (natural) only.
[4]Possibly includes evaporated salt.
[5]Construction and industrial sand and gravel.
[6]Crushed and dimension stone.
[7]Crushed stone only.

Table D-8.—Total water used per short ton of crude ore production, gallons

Commodity	1954	1962	1968	1973	1978	1983	1984
Metals:							
Copper	886	1,159	2,571	1,552	1,494	1,140	1,043
Gold and silver	NAp	[1]1,203	887	NAp	1,320	247	483
Iron ore	491	1,529	3,045	3,483	2,861	3,294	3,705
Lead and zinc	NAp	1,837	1,088	1,576	1,856	NAp	597
Uranium-vanadium	2,222	1,155	1,864	1,866	NAp	1,519	3,000
Other metals	NAp	NAp	998	1,129	1,231	2,135	1,283
Average	NAp	NAp	2,499	2,219	2,017	1,721	1,979
Nonmetals:							
Clays	[2]212	179	207	NAp	NAp	NAp	697
Phosphate rock	2,706	6,106	3,786	3,254	1,898	3,472	4,277
Potash, soda, borates	NAp	2,438	1,562	[3]2,132	[3]6,161	[3]6,122	[3]1,977
Rock salt	[2]625	[4]1,309	543	NAp	NAp	NAp	496
Sand and gravel[5]	[2]472	438	220	220	224	296	317
Stone[6]	[2]163	102	71	56	62	74	[7]132
Sulfur	2,656	3,123	3,095	NAp	NAp	NAp	[2]3,122
Other nonmetals	NAp	NAp	383	912	2,435	2,950	1,217
Average	NAp	NAp	467	367	402	560	636
Average, all nonfuel minerals	NAp	716	869	723	736	781	885

NAp Not applicable.
[1]Gold only.
[2]Marketable production.
[3]Potash and sodium carbonate (natural) only.
[4]Possibly includes evaporated salt.
[5]Construction and industrial sand and gravel.
[6]Crushed and dimension stone.
[7]Crushed stone only.

Table D-9.—New water intake per 1984 dollar of mine production, gallons

Commodity	1954	1962	1968	1973	1978	1983	1984
Metals:							
Copper	29	32	38	31	27	49	51
Gold and silver	46	[1]298	16	NAp	9	5	11
Iron ore	12	54	142	140	91	23	30
Lead and zinc	28	42	25	23	22	NAp	11
Uranium-vanadium	NAp	14	12	19	[2]84	[2]329	[2]285
Other metals	13	NAp	25	29	11	50	12
Average	22	NAp	65	57	48	28	30
Nonmetals:							
Clays	14	13	16	18	NAp	NAp	22
Phosphate rock	177	258	344	287	73	57	100
Potash, soda, borates	23	12	15	29	12	19	[3]16
Rock salt	26	[4]49	26	64	28	NAp	19
Sand and gravel[5]	92	81	43	41	39	52	47
Stone[6]	24	15	13	11	10	13	[7]17
Sulfur	27	48	31	46	56	NAp	14
Other nonmetals	27	NAp	6	23	47	57	17
Average	51	NAp	43	37	29	33	32
Average, all nonfuel minerals	38	47	52	46	37	31	31

NAp Not applicable.
[1]Gold only.
[2]Vanadium only.
[3]Potash and sodium carbonate (natural) only.
[4]Possibly includes evaporated salt.
[5]Construction and industrial sand and gravel.
[6]Crushed and dimension stone.
[7]Crushed stone only.

Table D-10.—Recirculated water per 1984 dollar of mine production, gallons

Commodity	1954	1962	1968	1973	1978	1983	1984
Metals:							
Copper	12	37	117	80	104	73	75
Gold and silver	22	[1]23	14	NAp	7	4	14
Iron ore	15	67	133	194	119	186	260
Lead and zinc	20	4	6	7	11	NAp	4
Uranium-vanadium	NAp	2	7	8	NAp	[2]157	[2]57
Other metals	26	NAp	41	63	51	132	74
Average	17	NAp	91	95	86	93	128
Nonmetals:							
Clays	4	3	3	NAp	NAp	NAp	8
Phosphate rock	210	592	428	574	188	404	559
Potash, soda, borates	32	59	80	40	126	68	[3]35
Rock salt	0	[4]15	17	NAp	NAp	NAp	21
Sand and gravel[5]	36	46	17	32	26	33	50
Stone[6]	2	5	2	2	5	5	[7]16
Sulfur	2	1	3	NAp	NAp	NAp	10
Other nonmetals	70	NAp	3	8	15	8	15
Average	30	NAp	38	40	41	56	76
Average, all nonfuel minerals	24	46	60	65	59	69	93

NAp Not applicable.
[1]Gold only.
[2]Vanadium only.
[3]Potash and sodium carbonate (natural) only.
[4]Possibly includes evaporated salt.
[5]Construction and industrial sand and gravel.
[6]Crushed and dimension stone.
[7]Crushed stone only.

Table D-11.—Total water used per 1984 dollar of mine production, gallons

Commodity	1954	1962	1968	1973	1978	1983	1984
Metals:							
Copper	41	69	155	111	131	122	126
Gold and silver	68	[1]321	30	NAp	16	9	25
Iron ore	27	121	275	334	210	209	290
Lead and zinc	48	46	31	30	33	NAp	15
Uranium-vanadium	NAp	16	19	27	NAp	[2]486	[2]342
Other metals	39	NAp	66	92	62	182	86
Average	39	NAp	156	152	134	121	158
Nonmetals:							
Clays	18	16	19	NAp	NAp	NAp	30
Phosphate rock	387	850	772	861	261	461	659
Potash, soda, borates	55	71	95	69	138	87	[3]51
Rock salt	26	[4]64	43	NAp	NAp	NAp	40
Sand and gravel[5]	128	127	60	73	65	85	97
Stone[6]	26	20	15	13	15	18	[7]33
Sulfur	29	49	34	NAp	NAp	NAp	24
Other nonmetals	97	NAp	9	31	62	65	32
Average	81	NAp	81	77	70	89	108
Average, all nonfuel minerals	62	93	112	111	96	100	124

NAp Not applicable.
[1]Gold only.
[2]Vanadium only.
[3]Potash and sodium carbonate (natural) only.
[4]Possibly includes evaporated salt.
[5]Construction and industrial sand and gravel.
[6]Crushed and dimension stone.
[7]Crushed stone only.

Table D-12.—Water use, by State and type of water, 1962 (29), million gallons

State	New water	Recirculated water	Total	Water discharged	Water consumed
Alabama	4,307	2,488	6,795	e3,633	e674
Alaska	17,001	3,227	20,228	16,516	485
Arizona	27,304	50,203	77,507	13,811	13,493
Arkansas	9,226	3,746	12,972	7,957	1,269
California	66,634	17,161	83,795	63,343	3,291
Colorado	9,869	6,424	16,293	7,718	2,151
Connecticut	2,274	711	2,985	2,105	169
Delaware	112	41	153	105	7
Florida	75,407	179,131	254,538	64,919	10,488
Georgia	14,760	1,882	16,642	13,918	842
Guam[1]	NA	NA	NA	NA	NA
Hawaii	328	0	328	327	1
Idaho	10,034	1,856	11,890	9,700	334
Illinois	9,192	10,595	19,787	8,986	206
Indiana	7,729	9,121	16,850	7,441	288
Iowa	2,011	3,937	5,948	1,966	45
Kansas	13,243	3,568	16,811	12,919	324
Kentucky	1,091	28	1,119	e1,006	e85
Louisiana	19,990	7,881	27,871	17,905	2,085
Maine	206	14	220	195	11
Maryland	5,195	2,313	7,508	4,804	391
Massachusetts	2,614	1,778	4,392	2,442	172
Michigan	47,253	36,636	83,889	46,084	1,169
Minnesota	102,314	99,224	201,538	97,938	4,376
Mississippi	6,873	3,656	10,529	6,694	179
Missouri	15,551	9,098	24,649	14,893	658
Montana	9,581	6,742	16,323	8,879	702
Nebraska	1,717	1,328	3,045	1,550	167
Nevada	8,577	3,817	12,394	5,211	3,366
New Hampshire	643	429	1,072	609	34
New Jersey	12,890	9,296	22,186	12,451	439
New Mexico	9,965	36,651	46,616	4,038	5,927
New York	20,172	11,376	31,548	18,064	2,108
North Carolina	7,898	3,775	11,673	7,224	674
North Dakota	2,112	3,372	5,484	2,040	72
Ohio	32,056	12,716	44,772	28,427	3,629
Oklahoma	5,214	10,379	15,593	5,104	110
Oregon	2,909	36	2,945	2,743	166
Pennsylvania	22,092	12,502	34,594	20,569	1,523
Puerto Rico[1]	NA	NA	NA	NA	NA
Rhode Island	506	86	592	461	45
South Carolina	3,887	1,956	5,843	3,812	75
South Dakota	3,351	1,245	4,596	2,705	646
Tennessee	57,304	97,168	154,472	37,819	19,485
Texas	37,426	14,869	52,295	31,622	5,804
Utah	22,171	21,595	43,766	9,960	12,211
Vermont	582	148	730	525	57
Virgin Islands[1]	NA	NA	NA	NA	NA
Virginia	5,374	3,132	8,506	4,827	547
Washington	7,879	1,150	9,029	7,469	410
West Virginia	6,452	3,858	10,310	4,491	1,961
Wisconsin	1,870	1,168	3,038	1,818	52
Wyoming	4,576	15,400	19,976	2,866	1,710
Total	757,722	728,913	1,486,635	652,609	105,113

[e]Estimated. NA Not available.
[1]U.S.-administered islands and commonwealth.

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